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Errata

Page 2, line 8, for "*arboreum*" read "*arborum*."
Page 6, footnote, for "*Caraguta*" read "*Caraguata*."
Page 14, line 7, for "PLATE 5" read "PLATE 1."
Page 14, line 2 from bottom, for "*Caraguta*" read "*Caraguata*."
Page 32, line 11 from bottom, for "*muticus*" read "*mutica*."
Page 38, line 13 from bottom, for "*racemosa*" read "*racemosum*."
Page 76, line 1, for "gareement" read "agreement."
Page 77, line 12 from bottom, for "genera" read "general."
Page 92, line 4, for "ertracted" read "retracted."
Page 100, line 4, for "AMSINKIA" read "AMSINCKIA."
Page 101, line 13, for "SIBERICA" read "SIBIRICA."
Page 109, line 6, for "wartius" read "Martius."
Page 109, line 10 from bottom, for "falsl" read "false."
Page 125, line 7 from bottom, insert the word "are" after "sure."
Page 127, line 16, insert a semicolon after "posterioribus."

Errata (*Continued*)

Page 127, line 23, for "zsooporis" read "zoosporis."
Page 143, Fig. 7, the lower right hand "S" should be "S^1."
Page 156, line 12, for "1902" read "1901."
Page 166, lines 1 and 6 from bottom, for "*hyalina*" read "*hyalinus.*"
Page 167, line 14, for "HYALINA" read "HYALINUS."
Page 180, line 12, for "PENTSTEMON" read "PENSTEMON."
Page 189, line 9, for "*Pentstemon*" read "*Penstemon.*"
Page 195, line 5, for "*Bermudianum*" read "*Bermudiana.*"
Page 197, line 8 from bottom, omit "with."
Page 208, after explanation of FIG. 1 add "$\times$ 3."
Page 224, line 16, for "*corrugatus*" read "*corrugata.*"
Page 226, line 9, for "*Polystitictus*" read "*Polystictus.*"
Page 228, line 18, for "MULITPLEX" read "MULTIPLEX."
Page 241, line 16, for "NOTHOLEANA" read "NOTHOLAENA."
Page 242, line 1, for "MACHROSTACHYA" read "MACROSTACHYA."
Page 242, line 16, for "RINGENS" read "RIGENS."
Page 244, line 8 from bottom, for "VAUQUELINA" read "VAUQUELINIA."
Page 245, lines 24 and 26, for "PAROSELLA" read "PAROSELA."
Page 247, line 7, for "CHOLOROTICA" read "CHLOROTICA."
Page 248, line 12 from bottom, for "PENTSTEMON" read "PENSTEMON."
Page 271, line 22, for "spathe" read "sheath of leaf."
Page 271, line 6 from bottom, for "leaves" read "branches."
Page 275, line 4, for "*Tinantia*" read "*Tradescantia.*"
Page 291, line 15 from bottom, for "herbarium of Cornell University" read "U. S. National Herbarium."
Page 292, line 19, for "Aented" read "Oersted."
Page 320, lines 5 and 13 from bottom, for "*Entothia*" read "*Endothia.*"
Page 323, line 7, for "*Plasmopora*" read "*Plasmopara.*"

Vol. 49 No. 1

BULLETIN

OF THE

TORREY BOTANICAL CLUB

JANUARY, 1922

Epiphyllous plants of certain regions in Jamaica*

Louis J. Pessin

(WITH PLATE 1 AND ONE TEXT FIGURE)

The great variety and luxuriant growth of the epiphyllous plants seen in Jamaica in the summer of 1919 led the writer to study them from two points of view: first, their distribution in relation to climatic conditions; second, their histological relation to the leaves bearing them, in order to determine whether these epiphytes are to any degree parasitic. The study of the distribution and environment of the epiphyllous plants was made in the field. The relation of the epiphyll to its supporting leaf was studied by histological methods in the laboratory.

Historical

Very little is known about epiphyllous plants today, in spite of the fact that they have long interested botanists. As early as 1875 Berkeley (1) reported the occurrence of epiphyllous lichens growing on the leaves of the tea plant; some of these apparently epiphyllous forms showed marked parasitic adaptation. Such forms were found in abundance in warm moist regions. Two of the forms observed by Berkeley were regarded as species belonging to the genus *Strigula*.

A few years after Berkeley's paper appeared, Cunningham (2) reported on an epiphyllous lichen and an epiphyllous alga, *Mycoidea parasitica*, parasitic on leaves of *Mangifera indica*, *Croton* and *Rhododendron*.

[The Bulletin for December (48 : 315–363) was issued February 28, 1922.]

* Botanical Contribution No. 69 from the Johns Hopkins University.

Marshall Ward (6) worked on an epiphyllous lichen which he believed to be the one worked on by Cunningham. He observed no penetration of the tissues of the supporting leaf by the lichen and therefore decided that it was not parasitic. He did find, however, one or more cross walls in the palisade cells of the supporting leaf beneath the epiphylls, which formed three or four layers of these cells instead of the normally single layer.

Schmidle (5) found species of *Trentepohlia arboreum* and *T. aurea* as well as *Phycopeltis microcystis* quite common as epiphyllous forms in Samoa. Massart (3) found that some orchids pass their entire existence on a single leaf. He found also that the epiphyllous floras differ in different regions. Algae and liverworts are the most common epiphyllous forms, while mosses acquire the epiphyllous habit only in very humid ravines.

OBSERVATIONS AND METHODS

Specimens of epiphyllous plants were collected in various regions in the Blue Mountains of Jamaica. The field observations were made during June and July, 1919, in the following places: Cinchona Plantation (5,000 feet), Morce's Gap (4,934 feet), New Haven Gap (5,600 feet), Green River Valley (3,000 feet), Markham Hill (5,800 feet), Vinegar Hill Road (4,500 feet), Clyde River Valley (4,500 feet) and Blue Mountain Peak (7,428 feet).

Material was either pressed or preserved in glycerine in 4 per cent formaldehyde, or in 60 per cent alcohol. For careful histological study, material was fixed in chromoacetic acid and preserved in 70 per cent alcohol until finally dehydrated, embedded, cut and stained with the Flemming's triple stain. In some cases material was left unstained for comparison.

The Cinchona Plantation is situated on a spur running south from the Blue Mountains at five thousand feet above sea level. The temperature varies between the extremes of 48° and 82° F. The vegetation of the garden about the residence of the Cinchona Plantation consists largely of introduced plants, many of which are Himalayan, Australian and Cape of Good Hope species. There are also native tree ferns, orchids, bromeliads, and many other transplanted native species. The banks along the trails outside the garden are covered mostly by native ferns interspersed

with, or on the north side of Cinchona Hill largely replaced by, *Hedychium coronarium*.

During the wet season Cinchona is enveloped in clouds for days at a stretch and the rains are very heavy and frequent. In spite of this abundance of moisture at certain times of the year, epiphyllous plants are rather scarce on the south side of Cinchona Hill. Only one hepatic, two species of algae and a few kinds of lichens were found growing there. Of these *Trentepohlia* grows in damp or shaded places on the ground, on the bark of trees and on the leaves of certain plants. Lichens, the most common of which belong to the genus *Sticta*, grow abundantly on certain plants. Some of the leaves of *Callistemon lanceolatum*, for instance, are almost completely covered by this lichen. In a few cases the leaves of *Hedychium* were found sprinkled with a reddish disk-like alga belonging to the genus *Phycopeltis*. The epiphyllous flora of this region is evidently not a rich one (see TABLE I, A).

At Morce's Gap, two miles north of Cinchona and at about the same level, is found a characteristic tropical montane rain forest. Here moisture is abundant at all seasons of the year. On the windward side of the mountains everything reeks with moisture; clouds drift constantly through these dense forests and rain falls frequently during eight months of the year. The dense vegetation, except on the ridges, is usually dripping wet. Very rarely do the sun's rays penetrate to the floor of these forests. Ferns carpet the floor and cover the walls of the steep-sided ravines. Tree ferns, such as *Alsophila* and *Cyathea*, are very common, many of them having trunks four or five inches thick and thirty feet high or more. Species of the genera *Marattia*, *Danaea*, *Polypodium* and *Elaphoglossum* are very abundant. Such forms as *Blechnum attenuatum* and many species of *Trichomanes*, *Hymenophyllum*, *Polypodium* and *Elaphoglossum* have been compelled to adopt either the climbing or the epiphytic habit in the intense competition for sunlight. *Podocarpus*, *Hedyosmum*, species of *Piper* and many other dicotyledonous trees and shrubs, together with numerous herbaceous plants, are scattered through these woods, increasing the struggle for existence and making the competition for light more keen.

In such an environment epiphyllous plants are very abundant.

TABLE I

EPIPHYLLOUS PLANTS OF JAMAICA

Region	Supporting plant	Algae	Lichens	Hepaticae	Musci
A. Cinchona Plantation, 5000 ft. alt.; South exposure.	*Callistemon lanceolatum*		*Parmelia* sp. *Sticta* sp. *Usnea* sp. A form of Pilocarpaceae	*Cololejeunea diaphana*	
	Hedychium coronarium	*Phycopeltis* sp. *Trentepohlia aurea*	*Lopadium* sp.		
	Pittosporum tobira	*Phycopeltis* sp.			
B. Morce's Gap, 4934 ft. alt.; north exposure.	*Elaphoglossum latifolium*	*Desmidium* sp. *Nostoc* sp. *Phycopeltis* sp. *Pinnularia* sp. *Scytonema* sp. *Staurastrum* sp.		*Cololejeunea* sp. *Cololejeunea diaphana* *Crossotolejeunea* sp. *Diplasiolejeunea pellucida* *Metzgeria furcata* *Microlejeunea* sp. (?)	
	Hedychium coronarium	*Phycopeltis* sp.		*Crossotolejeunea* sp. *Aphanolejeunea* sp. *Metzgeria furcata* *Cololejeunea diaphana* *Diplasiolejeunea pellucida* Schiffn.	
	Hedyosmum arborescens Sw.			*Crossotolejeunea* sp. *Lejeunea flava*	

TABLE I—*Continued*

Region	Supporting plant	Algae	Lichens	Hepaticae	Musci
B. Morce's Gap—*Continued.*	*Mangifera indica*	*Phycopeltis* sp.	Undetermined species*		
	Podocarpus coriaceus	*Phycopeltis* sp.		*Crossotolejeunea* sp. *Lejeunea flava*	
	Polypodium sp.		Undetermined species*		*Clastobryum americanum*
C. New Haven Gap, 5600 ft. alt.; north exposure.	*Stelis ophioglossoides*	*Phycopeltis* sp. *Trentepohlia aurea*			
	Trichomanes sp.			*Crossotolejeunea* sp.	
	Blechnum attenuatum	*Phycopeltis* sp. *Pinnularia* sp. *Nostoc* sp. *Scytonema* sp.		*Cololejeunea diaphana* *Crossotolejeunea* sp. *Diplasiolejeunea pellucida* *Drepanolejeunea campanulata* *Lophocolea* sp. *Metzgeria furcata* *Taxilejeunea* sp.	*Mittenothamnium reptans*
	Clusia havetioides	*Pinnularia* sp. *Nostoc* sp. *Scytonema* sp.	*Parmelia* sp.	*Aphanolejeunea* sp. *Aphanolejeunea sicaefolia* *Diplasiolejeunea pellucida* *Drepanolejeunea campanulata* *Cololejeunea diaphana* *Lejeunea flava* *Metzgeria furcata* *Microlejeunea* sp.	*Mittenothamnium reptans*

* Up to the present the writer has been unable to have some of the epiphyllous lichens definitely determined.

TABLE I—*Continued*

Region	Supporting plant	Algae	Lichens	Hepaticae	Musci
New Haven Gap—*Continued.*	*Monoclea Gottschei*				*Mittenothamnium reptans*
	Plagiochila sp.			*Riccardia* sp.	*Mittenothamnium reptans*
	Rhododendron sp.		*Phylloporina epiphylla* Undetermined species		
D. Vinegar Hill Road, 4500 ft. alt.; north and west exposures.	*Asplenium* sp.			*Cololejeunea* sp. *Cololejeunea diaphana* *Crossotolejeunea* sp. *Diplasiolejeunea pellucida* *Drepanolejeunea campanulata* *Metzgeria furcata*	
	Clusia havetioides	*Nostoc* sp. *Phycopeltis* sp. *Pinnularia* sp.	*Parmelia*	*Cololejeunea* sp. *Diplasiolejeunea pellucida* *Drepanolejeunea campanulata* *Lejeunea flava* *Lophocolea* sp. *Metzgeria furcata* *Taxilejeunea* sp.	
	*Elaphoglossum latifolium**	*Chroococcus* sp. *Gleocapsa* sp. *Nostoc* sp. *Phycopeltis* sp. *Scytonema* sp.		*Cololejeunea diaphana* *Crossotolejeunea* sp. *Lejeunea flava* *Metzgeria furcata*	*Mittenothamnium reptans*

* On a leaf of this species the seed plant *Caraguta Sintenesii* was likewise found living as an epiphyll.

TABLE I—*Continued.*

Region	Supporting plant	Algae	Lichens	Hepaticae	Musci
D. Vinegar Hill Road—*Continued.*	*Epidendrum* sp.		Undetermined species.	*Drepanolejeunea campanulata*	
	Polypodium Phyllitidis			*Cololejeunea* sp. *Cololejeunea diaphana* *Crossotolejeunea* sp. *Diplasiolejeunea pellucida* *Drepanolejeunea campanulata* *Drepanolejeunea crucianella* *Lophocolea* sp. *Metzgeria furcata* *Taxilejeunea* sp.	*Fissidens* sp.
E. Blue Mountain Peak, 7428 ft. alt.; northeast exposure.	*Podocarpus coriaceus*	*Phycopeltis* sp.			
F. Clyde River Valley, 4000 ft. alt.; north and west exposures.	*Citrus Limonium*	*Phycopeltis* sp. *Scytonema* sp. *Trentepohlia aurea*	*Coenogonium* sp. *Collema* sp. *Lecanora* sp. *Pannaria rubiginosa* *Pyrenula* sp. Undetermined species.	*Aphanolejeunea* sp. *Cololejeunea* sp. *Diplasiolejeunea pellucida* *Drepanolejeunea campanulata* *Lejeunea flava* *Metzgeria furcata*	

Here one finds plants of many types growing on the soil; on these grow various plants as epiphytes and on these in turn grow other epiphytes. A remarkable diversity of epiphytic forms can be found on one plant, and some of the forms are wonderfully adapted to their epiphytic mode of life. These epiphytes occur on every patch of dead or living plant surface that receives even a moderate supply of light. One finds on a single leaf here such forms as algae, lichens, hepatics, mosses and, at times, even seed plants, not to mention occasional fungi and minute epiphyllous animals. It is rather strange that not a single fern prothallus has been found on any of the leaves of this region, though numerous sporangia were present and probably spores also on many different kinds of leaves. In TABLE I, B, are listed the different kinds of epiphyllous forms found near Morce's Gap.

The climatic conditions of New Haven Gap do not differ markedly from those of Morce's Gap. The temperature is nearly the same, ranging annually from 40.5° to 83° F., and the floor of the forest is constantly moist and shaded. Here again one finds the characteristic rain forest vegetation. The epiphyllous plants here are quite as abundant as at Morce's Gap and consist mainly of algae, hepatics, and mosses. The leaves of the climbing plants of this locality are well inhabited by epiphyllous forms. The leaves of *Clusia havetioides* and of such ferns as *Blechnum attenuatum*, *Elaphoglossum latifolium* and *Polypodium Phyllitidis* serve most frequently as the substratum for epiphylls (see PLATE 1). A glance at TABLE I, C, gives one a fair notion of the groups of epiphyllous plants found in the New Haven Gap region.

Going northward from Morce's Gap along the upper eastern slopes of the Mabess Valley the trail is particularly interesting as it presents a splendid view of the ravines. The crowns of the tree ferns carpet many side ravines of the valley. The huge lianes, the numerous orchids, the wild pines and the purplish filmy ferns mantle the branches of many trees and the species of *Asplenium*, *Blechnum* and *Polypodium*, along with the walking fern (*Polystichum plaschnichianum*), spread over the banks. One does not have to walk off the trail to find numerous epiphyllous plants. The upper leaves of many of the low trees on the Vinegar Hill Road are completely covered by them. TABLE I, D, shows the great variety of epiphyllous forms found in this region.

On TABLE I, E and F, are indicated the epiphyllous plants observed on the Blue Mountain Peak and in the Clyde River Valley. In the former, though there is always an abundance of moisture, the epiphyllous flora is not a rich one, owing probably to the frequent heavy rains, the rather low temperature and the occasional strong winds. Those of the Clyde River Valley occur chiefly on trees growing along streams, where there is sufficient shade and a humid atmosphere.

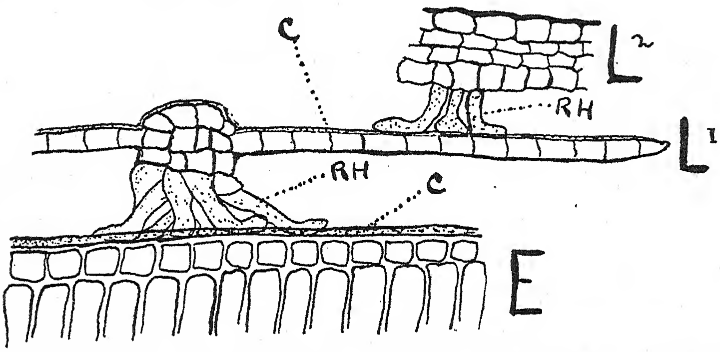

FIG. 1. Part of transverse section of a leaf of *Elaphoglossum latifolium* (*E*) with the rhizoids (*Rh*) of an epiphyllous liverwort (L^1) pressed into its cuticle. This liverwort in turn bears another epiphyllous liverwort (L^2), which is likewise attached by its rhizoids (*Rh*).

In general, observations in these Blue Mountains of Jamaica show that the epiphyllous members of each group of plants are limited to certain regions where climatic conditions are suitable for such growth. Thus, Algae, Hepaticae, and Musci usually thrive best on the windward side of the mountains and are abundant only in very damp and very shady woods. Epiphyllous lichens, on the other hand, do not require very warm, humid, and shady places but are also found in relatively dry regions. It was rather difficult to ascertain with any degree of definiteness the exact age of the leaves which bore epiphyllous plants, but it is safe to state that none are present on very young leaves. As a rule they do not appear on leaves until the latter are one or two seasons old.

In order to determine the relation between the epiphyllous forms and the plants on which they grow, cross sections were made of the leaves of *Elaphoglossum latifolium*, *Clusia havetioides*,

Polypodium Phyllitidis and *Mangifera indica.* The leaves of *Elaphoglossum latifolium* were those chiefly used because of the abundance on them of epiphyllous liverworts in various stages of development. Sections of leaves of *Mangifera indica* were also studied to determine the relation of an epiphyllous lichen to the mango leaf.

Sections of the leaves bearing epiphyllous hepatics showed characteristic thickened, club-like rhizoids arising in groups from the stem of the creeping liverwort. These rhizoids are sunken into the cuticle of the supporting leaf as if pressed in by some external force. The rhizoids broaden at their lower ends and flatten out as is shown in TEXT-FIG. 1. This is true even of the rhizoids of one epiphyllous liverwort when growing upon another, for one sometimes finds two or more tiers of epiphylls growing upon a fern or a dicotyledon. The rhizoids of the upper hepatic are in such cases decidedly flattened against the delicate leaves of the lower liverworts. This too is shown in the figure. The important point to be noted is that the rhizoids of the epiphyllous form were not observed to penetrate the tissues of the supporting leaf. Nor was there evident any abnormality in the internal structure of the supporting leaf, such as might conceivably be produced by the shade or by the weight of the epiphylls on the leaf or, possibly, by some substance such as an organic acid excreted by the rhizoids on the liverwort.

The leaves of *Mangifera indica* bore numbers of orange-red disk-like plants of a species of *Phycopeltis.* Among these orange-red specks there were also minute grey patch-like lichens resembling those described by Cunningham (3) and Ward (9). The relation between these lichens and the mango leaf on which they grew has not been definitely determined. The sections of the mango leaf thus far studied showed no modifications of its tissues and no penetration by the lichens.

DISCUSSION

The problem of the evolutionary origin and individual development of the epiphyllous plants is a complex one which still requires much careful investigation. Schimper (4) observed that epiphytic seed plants commonly originate on their support through seeds.

The scattered seeds germinate on the trunk, branches, or leaves of a tree or shrub and, with adequate moisture and other nutritive material, develop into epiphytes. He divides the fruits and seeds of epiphytes into three categories: first, those transported by birds, monkeys and other tree-inhabiting animals; second, those which are very light and may be transported by the wind and which may readily catch in the crevices of the bark and germinate there; third, those seeds which are especially adapted to be carried by the wind. Such seeds usually possess either hairs or wings or inflated coats which aid their distribution.

It is conceivable that a great many of the epiphyllous forms here being considered arise from spores, for spores have been found on many leaves. The epiphyllous liverworts evidently arise often from gemmae, for many such gemmae in the process of development have been found on leaves. The spores of liverworts, on the contrary, have rarely been found germinating on leaves. The observations thus far made indicate that many an epiphyllous hepatic or moss makes its start on the host by creeping up the stem of the support from the ground or up the petiole from the stem. As it climbs upward it dies off from below and when its younger part reaches the leaves it spreads over the surface and becomes strictly an epiphyllous form. Secondly, epiphyllous forms may be lodged upon the host by the agency of water. When during a rain the water flows down over the leaves and branches of a tree in the rain forest, it breaks off the hepatics and mosses and other plants from the surface of the stem or leaf and washes them down on the leaves below, where they continue to grow, covering the leaf in the course of time with a dense mat. Such is probably the explanation of the fact that in most cases the lower leaves possess the greatest number of epiphyllous plants, though, of course, lower leaves are older, better shaded, and are surrounded by moist air. It is probable also that the epiphyllous plants found on the dorsal sides of certain overturned leaves arise in the manner just described. The fact that no epiphyllous plants were observed on the lower sides of leaves still in normal position is evidence that these plants are propagated largely by these fragments. If it were commonly by spores we should expect these, at least occasionally, to stick to the underside of a

leaf. Such cases, however, are extremely rare. In a third possible method of dispersal, spores, gemmae, or seeds may be washed down by the dripping water from above, or may be blown from adjacent plants by the wind. This method is particularly common among algae and lichens. The first two types of vegetative propagation seem to be the commoner ones, for in many instances the epiphyllous forms growing on the stem have actually been observed to spread over the surface of the leaf. Moreover, many of the forms found on the leaves occur likewise on the stem of the supporting plant. This is particularly true of hepatics and mosses. In lichens, however, the case may be different. There the alga, as well as the component fungus, may often be present separately on the leaf; each may reach the leaf in the form of loose spores or fragments, and there combine to give rise to the lichen itself.

Massart (3) failed to find in Java any epiphyllous pteridophytes and phanerogams. In the tabulated lists of epiphyllous plants of Jamaica in this paper it will be noted that no pteridophytes have been found. Although many fern sporangia were observed among the epiphylls by the writer, no germinating fern spores or fern prothallia were seen. The writer, however, found a few epiphyllous phanerogams. These were very young plants of the genus *Caraguata* attached to the surface of the leaf, and apparently doing well. How much further their development would continue is hard to tell, for the substratum is not firm enough to support a mature wild pine; before the epiphyllous wild pine could have time to mature, the supporting leaf would probably be shed. The fact is, at all events, that no mature wild pines were found growing on leaves. According to Massart, the epiphyllous plants do not constitute a similar flora everywhere; in some localities this consists solely of thallophytes, in others of bryophytes. This is also true for Jamaica, where in certain regions only one type occurs, while in other regions numerous diverse forms are present.

Massart's suggestion that the leaf-inhabiting fungus has been derived from the epiphyllous plant is at least favored by the relation to its host of the alga *Cephaleuros*, which may have either the parasitic or the epiphytic mode of life. On the other hand, there are still some fungi which possess the epiphyllous habit, such as *Metiola astrina* and a few others. There seems little doubt that

a careful study of epiphyllous plants would throw some light on the origin of parasitism, such as that of leaf-infesting fungi.

SUMMARY

1. Epiphyllous plants of diverse selected regions in Jamaica were studied in the field and collected for laboratory study in Baltimore.

2. The results of the field observations were tabulated so as to give at a glance a general idea of the distribution of these epiphyllous plants in relation to the altitude, average temperature, and average humidity of their various habitats.

3. The possible modes of attaining the epiphyllous position are:

(*a*) Continual growing forward and dying off below, of hepatics and mosses, until they reach and cover the leaf.

(*b*) By distribution of spores, gemmae or seeds through the agency of rain and wind. This is especially true for algae and fungi.

(*c*) Propagation by displaced fragments of mature lichens, hepatics, and mosses.

4. An abundance of humidity, moderate temperature, and a relatively calm atmosphere encourage an abundant epiphyllous growth.

5. Histological studies of epiphyll-bearing leaves of *Elaphoglossum latifolium*, *Clusia havetioides* and *Mangifera indica* revealed no apparent penetration of the leaf by any part or organ of the epiphyll.

6. The rhizoids of epiphyllous hepatics are especially adapted for the epiphyllous habit by becoming thickened, by flattening out and by being pressed into the cuticle of the leaf, thus firmly attaching the epiphyll to the leaf and preventing its being blown or washed off easily.

7. It is conceivable that the shade produced by the epiphyll, the accumulation of the organic material, the possible excretion of acids and other substances by its rhizoids may have some physiological effect on the supporting leaf.

8. A careful study of the epiphyllous mode of life will, it is believed, bring out some close relations between parasitism and

the epiphyllous habit. Parasitism is possibly an advanced, specialized phase of epiphytism.

The writer is indebted to the Botanical Department of the Johns Hopkins University for the opportunity of going to Jamaica. The writer wishes to thank particularly Professor Duncan S. Johnson for suggesting this problem, for taking the photographs reproduced on PLATE 5, and for helpful advice in carrying on the work. Acknowledgments are due Professor Alexander W. Evans for the determination of most of the epiphyllous hepatics; to Mrs. N. L. Britton of the New York Botanical Garden for the determination of some of the epiphyllous mosses; and to Professors C. C. Plitt and Lincoln W. Riddle for the determination of certain epiphyllous lichens.

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Explanation of plate 1

FIG. 1. Leaf of *Polypodium Phyllitidis*, showing epiphyllous hepatics and mosses.

FIG. 2. Leaf of *Elaphoglossum latifolium*, showing a luxuriant growth of epiphyllous plants; a small wild pine, *Caraguta Sintenesii*, can be seen on the right hand margin.

The genus Catinella

ELIAS J. DURAND

The genus *Catinella* was established by Boudier* for a single species, of rather indefinite relationship, which has commonly been identified as *Peziza olivacea* Batsch. While Batsch's plant is indeterminable when tested according to present day standards of specific limitations, the fungus which has gone by that name is well known, being clearly described by Massee,† and nicely figured by Boudier.‡ The synonymy listed below emphasizes not only the truth of Boudier's statement that the species has been included sometimes in one genus, sometimes in another, but that it has been referred by various writers to several different families as well. The inoperculate asci and intense reaction to caustic potash remove it from the Pezizaceae, where the bright color and fleshy consistency of the fresh young plants at first seem to place it, and to which it has been referred by Saccardo, Rehm and others. The somewhat gelatinous nature of the excipulum has suggested the Bulgariaceae to Fries, Karsten and others, but that character is certainly not conspicuous enough to associate the plant with *Bulgaria inquinans* or *Sarcosoma rufum.* Moreover, a truly gelatinous tissue does not become friable on drying. The present writer is inclined to the opinion of Berkeley, Phillips, Massee and Boudier that its affinities are more properly with the Patellariaceae, such, for example, as *Karschia.* The genus may be characterized as follows:

A genus of the Patellariaceae. Ascomata fleshy and somewhat gelatinous when fresh, becoming friable when dry, sessile, attached to the substratum by radiating, dark fibers; excipulum entirely parenchymatous, becoming deep violet with KOH; asci opening by a pore, not blue with iodine; spores eight, continuous, pale brown; asci and paraphyses agglutinated at the tips to form an epithecium.

* Hist. Class. Disc. Eur. 150. 1907.
† Brit. Fungus-Fl. 4: 94. 1895.
‡ Icon. Myc. 3. *pl. 452.*

Species two, as follows:

Spores 7–11 × 4–5 µ. 1. *C. nigro-olivacea.*
Spores 13–15 × 6–7 µ. 2. *C. elastica.*

1. **Catinella nigro-olivacea** (L. v. S.) Durand, comb. nov.

?*Peziza olivacea* Batsch, Elench. Fung. 127. *pl. 12. f. 51.* 1783.
Peziza nigro-olivacea L. v. S. Syn. Car. 121. 1822.
Patellaria pulla β nigro-olivacea Fr. Syst. **2**: 160. 1822.
Bulgaria nigrita Fr. Elench. **2**: 16. 1830.
Lemalis rufo-olivacea L. v. S. Syn. N. Am. n. 1089. 1834.
Rhizina nigro-olivacea Curr. Trans. Linn. Soc. **24**: 494. *pl. 51. f. 10–12* (*fide* Phillips).
Peziza viridi-atra B. & C. Jour. Linn. Soc. Bot. **10**: 369. 1868.
Patellaria violacea B. & Br. Jour. Linn. Soc. Bot. **14**: 108. 1875 (*fide* Massee *l.c.*).
Patellaria hirneola B. & Br. Jour. Linn. Soc. Bot. **14**: 108. 1875 (*fide* Massee *l.c.*).
Patellaria applanata B. & Br. Jour. Linn. Soc. Bot. **14**: 108. 1875.
Peziza fuscocarpa Ell. & Hol. Jour. Myc. **1**: 5. 1885.
Patellaria olivacea Phill. Brit. Disc. 361. 1887 (Batsch ?).
?*Humaria olivacea* Sacc. Syll. **8**: 148. 1889 (Batsch ?).
Pezicula viridi-atra Sacc. Syll. **8**: 315. 1889.
Phaeopezia fuscocarpa Sacc. Syll. **8**: 474. 1889.
Bulgariella pulla β nigro-olivacea Sacc. Syll. **8**: 638. 1889.
Bulgariella nigrita Sacc. Syll. **8**: 638. 1889.
Patinella violacea Sacc. Syll. **8**: 770. 1889 (*fide* Massee).
Patinella olivacea Sacc. Syll. **8**: 770. 1889 (Batsch ?).
Patinella hirneola Sacc. Syll. **8**: 771. 1889 (*fide* Massee).
Patinella applanata Sacc. Syll. **8**: 771. 1889.
Humaria marchica Rehm, Rabenh. Kypt.-Fl. **1**[3]: 952. 1894.
Phaeopezia marchica Sacc. Syll. **11**: 415. 1895.
Aleurina marchica Sacc. & Syd. Syll. **16**: 739. 1902.
Humaria fuscocarpa Morgan, Jour. Myc. **8**: 189. 1902.
Aleurina fuscocarpa Sacc. & Syd. Syll. **16**: 739. 1902.
Catinella olivacea Boud. Hist. Class. Disc. Eur. 150. 1907 (Batsch ?).

Ascomata solitary or two or three together, sessile, attached to the substratum by numerous, radiating, dark brown fibers most

conspicuous in young plants; at first spherically closed, then opening out so as to become successively cup-shaped, saucer-shaped, finally applanate, with a permanently upturned margin; very young plants greenish yellow, becoming deeper and darker green, finally blackish olive when old, fleshy and somewhat gelatinous when fresh, 3–10 mm. in diameter, the majority 3–5 mm. On drying the disk becomes olive-black, the exterior brownish, somewhat furfuraceous or vertically striate, and the texture friable. *Excipulum* about 400 μ thick at the base, entirely parenchymatous, the ectal cells 18–20 μ in diameter, polygonal, with dark brown walls, becoming gradually smaller and yellow toward the hymenium, the superficial cells of the margin and sides projecting to form short, stout, obtuse, septate, flexuous, brown pili causing the surface to appear furfuraceous, those at the base much longer and radiating so as to form a small subiculum covering the substratum 2–3 mm. beyond the margin. On treatment with 1 per cent caustic potash the hymenium or whole flesh becomes deep violet and frequently yields a violet solution. *Hymenium* about 120–140 μ thick. *Asci* narrowly cylindric-clavate, apex rounded, not blue with iodine, 65–90 x 3–6 μ (mostly 70–80 μ). *Spores* eight, uniseriate, elliptic or elliptic-clavate, usually slightly narrowed near the middle so as to appear slipper-shaped, continuous, two-guttulate, pale olive-brown to deep brown, 7–11 x 4–5 μ (majority 8–10 μ); *Paraphyses* cylindric, septate, rarely branched, somewhat longer than the asci, the tips agglutinated with amorphous matter to form an epithecium.

On rotten wood, especially of old, moist, carious, decorticated logs, not abundant but widely distributed in eastern North America and the West Indies; also in Europe and Ceylon.

This is one of our most peculiar and attractive discomycetes. "In its young state it is truly *Peziza*-like, and very beautiful." While easily recognizable at sight when once understood, it has been described as new over and over again until very few fungi have a greater multiplicity of names. While this may be the species to which Batsch applied the name *Peziza olivacea*, his brief description and crude figures are much too inadequate to justify more than surmise, and may apply equally well to numerous other species. The apparent rarity of our plant in central Europe makes it still more improbable that Batsch had seen it. *P. olivacea* is simply one of the numerous names of fungi handed down from the pre-Persoonian period, the mycological stone age, which are absolutely indeterminable according to present taxonomic standards,

and which should therefore be dropped completely and no longer allowed to encumber the mycological literature.

The first certainly identifiable name applied to the plant under consideration is the one adopted in the present paper. While Schweinitz's type, from North Carolina, is missing from his herbarium, there is a specimen marked "rotten wood. Beth." under the name "*Lemalis pulla β nigro-olivascens* Schw. No. 1089." This label involves a curious switching of names and an error in spelling as follows: *Peziza nigro-olivacea* L. v. S. was included by Fries in his Systema as "*Patellaria pulla β nigro-olivacea*." In 1834, Schweinitz transferred the species to the genus *Lemalis*, and changed the specific name so that it appeared as "1089. 4. *L. rufo-olivacea*, L. v. S., Syn. Car. 1220, *Peziza nigro-olivacea;* Salem et Bethlehem differt specifice a priori [*L. pulla* Fr.]". At a later date, Dr. Michener, in mounting and arranging Schweinitz's fungi, restored the original specific name (*nigro-olivacea*) to the label, but misspelled it "*nigro-olivascens*." The presence of numbers and references in each case leaves no doubt that the specimen now in the Schweinitzian Herbarium is the one referred to in 1834 as from Bethlehem.

Although Fries stated that he had seen a specimen of *Peziza nigro-olivacea*, there seems to be no Schweinitzian material so labeled in the Friesian Herbarium, at Upsala. However, there is a specimen called "*Lemalis rufo-olivacea* Schw.," from Curtis, as well as one marked "*Peziza applanata* ex herb. Schweinitz." While both are typical *Catinella nigro-olivacea*, the latter is quite different from the specimen in Schweinitz's own herbarium called *P. applanata*.

In 1830, Fries described as *Bulgaria nigrita* a plant collected in Russia by Weinmann. So far as the writer can discover, no more recent collection has been referred to this species, which has remained practically unknown for nearly a century. In the Friesian Herbarium is a specimen marked "*Bulgaria nigrita*, Petersburg," in Elias Fries's own hand, which is in all probability the original type. When the writer saw it, in 1904, he was at once impressed with its gross resemblance to the American plant. Subsequent microscopical examination removed all doubts as to their specific identity.

During the Berkeleyan period this species was collected occasionally in various parts of the world, and almost as often described as new. Material from Cuba (Wright, No. 369) was given the name *Peziza viridi-atra* B. & C. Examination of the type, at Kew, shows it to be identical with the Schweinitzian plant. Saccardo placed it in *Pezicula*. Specimens from Ceylon were called *Patellaria applanata* B. & Br. The writer has not seen the type, but Massee, on examination, declared it to be *Patinella olivacea* (*C. nigro-olivacea*). On the basis of the same evidence the same writer included *P. violacea* B. & Br. and *P. hirneola* B. & Br., also from Ceylon, as synonyms. In the original description of *P. applanata* the authors mentioned a "United States specimen." Material so labeled in the herbaria of Fries and the Philadelphia Academy of Science, collected in South Carolina, by Curtis, has been examined, and certainly belongs here. Additional collections reported from Connecticut (Wright), Pennsylvania (Michener), and North Carolina (Curtis) have not been seen.

No specimen of *Rhizina nigro-olivacea* Curr. has been available to the writer. But since both Phillips and Massee (the latter after examination of the type) place it as a synonym of *P. olivacea*, there seems to be no doubt of its identity with *C. nigro-olivacea*.

Peziza fuscocarpa Ell. & Hol. was described from material collected in Iowa by Holway. It has been referred to *Phaeopezia* by Saccardo, to *Humaria* by Morgan, and to *Aleurina* by Saccardo & Sydow, and by Rehm. This specific name is the one under which the plant here considered has commonly been reported or distributed in America. The type is identical with *Peziza nigro-olivacea* L. v. S. The writer has received it from many localities and has had abundant opportunity to study it in the fresh condition in all stages of development.

Of all the references of the present species made by Saccardo, the most curious is that where *Peziza nigro-olivacea* L. v. S. is made a synonym of *Mollisia umbonata* (Pers.) Sacc. To Persoon's specific description are appended verbatim Fries's observations comparing Schweinitz's plant with *Patellaria pulla* Fr., a totally different plant from Persoon's. This confusion may be due to a mixing of notes.

Finally, the plant here considered was described as *Humaria marchica* by Rehm, from German material distributed by Sydow and examined by the writer.

While it has been demonstrated that *Catinella nigro-olivacea* has passed under about thirty different names, it may well be that others have escaped the writer's attention.

In the citation of specimens the following abbreviations have been used: CU, Herbarium of Cornell University; D, Durand Herbarium; F, Fries Herbarium; K, Kew Herbarium; Mo, Herbarium of the Missouri Botanical Garden; NY, Herbarium of the New York Botanical Garden; Phil, Philadelphia Academy; S, Schweinitz Herbarium.

MATERIAL EXAMINED

RUSSIA: Petersburg (F, type of *Bulgaria nigrita* Fr.).

GERMANY: Brandenburg, *Sydow* (NY, cotype of *Humaria marchica* Rehm, in Sydow, Myc. March. *2958*); Moravia, *Petrak* (D, as *Aleurina olivacea* [Batsch] v. Höhn.).

ONTARIO: Carleton Place, *Macoun* (NY); London, *Dearness* (CU, D, E. & E. N. Am. Fungi *2325*).

NEW HAMPSHIRE: Warren, *L. W. Riddle* (D).

NEW YORK: Ithaca, *Atkinson* (D); Varna, *Reddick* (D); Honeoye, *Durand* (D); Adirondack Mountains, Catskill Mountains, Old Forge, Kasoag, Big Indian, South Pond, Elisabethtown, *Peck* (A, as *Patellaria olivacea*).

PENNSYLVANIA: Bethlehem, *Schweinitz* (S); Springtown, *Witte* (NY); Mauch Chunk (Phil); Chester County, *Michener* (Phil).

NORTH CAROLINA: Blowing Rock, *Durand* (D).

SOUTH CAROLINA: *Curtis* (F, Phil).

LOUISIANA: Cloutierville & Abita Springs, *Langlois* (NY).

ARKANSAS: Camden, *C. J. Humphrey* (D).

OHIO: Preston, *Morgan* (NY).

MINNESOTA: Lakeville (D); St. Louis River, *Holway* (NY, Mo).

NORTH DAKOTA: Fargo, *Seaver* (NY, Mo, N. Dak. Fung. *28*, as *Phaeopezia fuscocarpa*).

IOWA: Mt. Pleasant, *Seaver* (D); Decorah, *Holway* (NY, type of *Peziza fuscocarpa*).

CUBA: *Wright 369* (K, type of *Peziza viridi-atra*)

2. **Catinella elastica** (Pat. & Gail.) Durand, comb. nov.

Phaeopezia elastica Pat. & Gail. Bull. Soc. Myc. Fr. **4**: 99. 1888.

Aleurina elastica (Pat. & Gail.) Sacc. & Syd. Syll. **16**: 739. 1902; Rehm, Ann. Myc. **1**: 515. 1903.

Ascomata sessile, solitary or in groups, 1–3 mm. in diameter, rich dark brown externally, black within, attached at the base by radiating brown fibers consisting of septate hyphae; margin thickened. *Excipulum* parenchymatous, of polygonal cells, the ectal ones with brown walls, those at the sides of the cup giving rise to short, septate, flexuous, brown pili, those at the base to stout, brown, radiating hyphae. *Asci* cylindric-clavate, apices rounded, not blue with iodine. *Spores* eight, uniseriate, elliptic, or elliptic-clavate, or slipper-shaped, continuous, brown, two-guttulate, 13–15 x 6–7 μ. *Paraphyses* cylindric, hyaline, septate, tips agglutinated with amorphous matter.

MATERIAL EXAMINED

VENEZUELA: on dead wood, Mapire, May, 1887, *A. Gaillard 6* (NY).

This species seems to differ from the preceding only in the larger spores. In the herbarium of the New York Botanical Garden is a specimen of what appears to be the original and only collection. The above description is that of the authors supplemented by notes drawn from the above mentioned specimen. In the original description the tissue is spoken of as elastic, somewhat like that of *Bulgaria*. The dried material is friable. It breaks up so that no complete ascus has been seen. The material becomes deep violet on treatment with KOH.

UNIVERSITY OF MINNESOTA

INDEX TO AMERICAN BOTANICAL LITERATURE

1908–1921

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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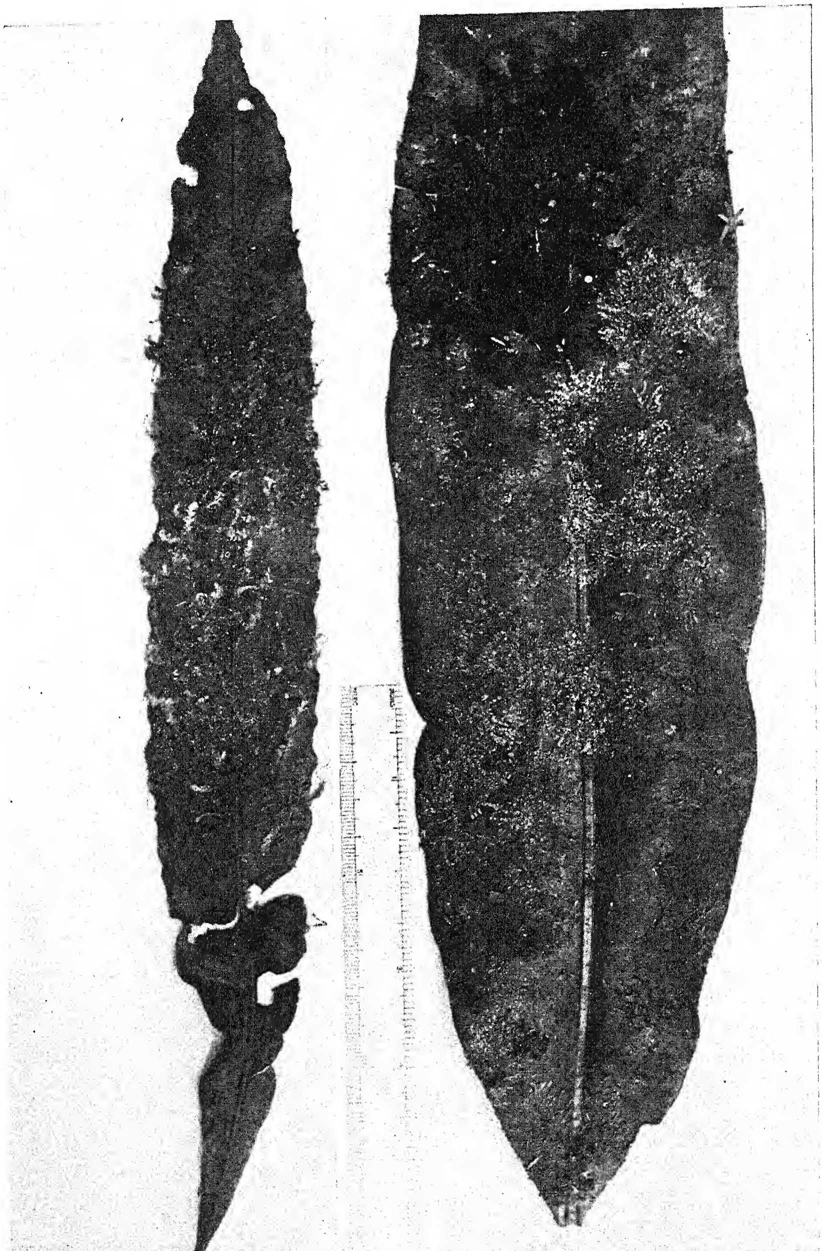

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PESSIN: EPIPHYLLOUS PLANTS OF JAMAICA

Vol. 49 No. 2

BULLETIN

OF THE

TORREY BOTANICAL CLUB

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Miscellaneous notes on plants of Southern California—I

PHILIP A. MUNZ AND IVAN M. JOHNSTON

Recent botanical collecting has added to our knowledge of the flora of Southern California and has made possible the presentation of the notes given in this paper. Collections cited as having been made by "*M & H*" were by Munz and Harwood, those by "*M, J & H*" were by Munz, Johnston and Harwood; other collections are not abbreviated. Specimens of all the plants mentioned are in the C. F. Baker Herbarium of Pomona College.

NOTHOLAENA SINUATA var. INTEGERRIMA Hook.

Notholaena sinuata var. *integerrima* Hook. Sp. Fil. 5: 108. 1864.

Locally abundant on a rocky hillside in a gulch back of the Bonanza King Mine, Providence Mountains, Mohave Desert, *M & H 3550* and *M, J & H 4224*. Our material is a fine match for the figure given by Eaton (Ferns of North America *pl. 39, f. 1.* 1879). New to California.

WOODSIA SCOPULINA D. C. Eaton

Woodsia scopulina D. C. Eaton, Canadian Nat. II 2: 90. 1865.

This fern, infrequent in the higher mountains of the middle and northern parts of the state, must be accredited a place in the fern-list of Southern California, as a few plants were collected in the Providence Mountains several miles south of the Bonanza King Mines. The single colony discovered, *M, J & H 4212*, was growing in the shelter of boulders in the bed of a dry gulch in the lower portions of the pinyon belt. The soil in which the plant

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grew was damp, not saturated, gravel; a water hole was situated a few hundred feet down the canyon and there was apparently a meager supply of water from underground sources. On the adjacent canyon walls were such typical xerophilous ferns as *Notholaena tenera, M, J & H 4232; N. Parryi, M, J & H 4236; Cheilanthes Feei, M, J & H 4215; C. Covillei, M, J & H 4015; Gymnogramme triangularis, M, J & H 4021;* and *Pellaea compacta, M, J & H 4018.*

NOTHOLAENA CALIFORNICA D. C. Eaton

Notholaena californica D. C. Eaton, Bull. Torrey Club **10**: 27. 1883.

The junior author collected a few plants of this fern high upon a precipitous south-facing cliff at Deadman Point, about ten miles southeast of Victorville. The collected plants were associated with an abundance of *Notholaena Parryi* and with fewer *Cheilanthes Covillei* and *Gymnogramme triangularis*. This collection now marks the most northern station for this species, at least in California, and at the same time makes the species first known as an element of the Mohave Desert flora. Maxon in his recent discussion (Contr. U. S. Nat. Herb. **17**: 603. 1916) has cited many specimens that show the distribution of this neat little plant. Johnston (Bull. So. Cal. Acad. **17**: 64. 1918) has recorded a second coastal and what is at the same time the most westerly known station on the mainland.

TRIODIA MUTICA (Torr.) Benth.

Tricuspis muticus Torr. U. S. Rep. Expl. Miss. Pacif. 4: 156. 1857.
Triodia mutica Benth.; Wats. Proc. Am. Acad. **18** : 180. 1883.

Abundant on a rocky pinyon-clad hillside near the Bonanza King Mine, in the Providence Mountains, *M, J & H 4132*. Previously known in California only from a collection made in the central Sierra Nevada (cf. Jepson, Fl. California 141. 1912). Determination by Mrs. Chase.

AGAVE UTAHENSIS Engelm.

Agave utahense Engelm. Bot. King. Exp. 497. 1871.

Common in rocky places in the pinyon belt of the Providence Mountains, *M, J & H 4302*. This is the "*Agave sp.*" reported by

Brandegee (Zoe 5: 153. 1903). Mulford has cited a collection made by Parish at Ivanpah (Rep. Missouri Bot. Gard. 7: 78. 1896).

YUCCA BACCATA Torr.

Yucca baccata Torr. Bot. Mex. Bound. Surv. 221. 1859.

The presence of this species in the Providence Mountains was reported recently by Mr. Parish (Bot. Gaz. 65: 336. 1918) and at a much earlier date by Dr. Engelmann (Trans. St. Louis Acad. 3: 44. 1873), so that all that remains for us to do is to add a few notes on its habits. This species and *Y. mohavensis* are very common in the vicinity of the Bonanza King Mine but, although growing in the same region, differ widely in habitats and habits, as well as in technical characters. *Y. baccata* grows on rocky, sunny hillsides in the pinyon belt and is a very late-flowering plant; for but few individuals were in flower during our visit to the mountains from May 21 to 24, 1920. On the other hand, *Y. mohavensis* grows along the foot of the mountains, below the pinyon belt, and flowers very early; for on the May visit fruit was set, flowering having been observed on an earlier visit during the last week in March. Our observations fully substantiated Mr. Parish's statement that *Y. baccata* was recognizable in the field by the lighter color of the leaves and the universal acaulescent habit.

Structurally the two species are very distinct. *Y. baccata* has large campanulate flowers, whose perianth segments do not spread from the base but remain erect and appressed about the ovary for a short distance before spreading, thus suggesting the tubular condition characteristic of the genus *Samuela* Trel. In *Y. mohavensis* the shorter segments spread from the very base and are more curved, thus making the flowers globose in shape.

The meager material that is available of *Y. baccata* suggests that there may be a major and a minor flower form. Mr. Brandegee's collection, reported as *Y. mohavensis* (Zoe 5: 153. 1903), Lemmon's 1884 collection at Ft. Mohave, and our *M, J & H 4114* all represent plants with conspicuously large flowers, the perianth-segments of which vary between 8 and 9.5 cm. in length. On the other hand, *Parish 10281* from the north end of the Providence Mountains and our *M, J & H 4113* from the south end of these

mountains have strikingly smaller corollas, the perianth-segments measuring 6–7 cm. in length. Under the original description Dr. Torrey quotes Bigelow to the effect that this species has perianth lobes 2½ or 3 inches (6.25–7.5 cm.) long, while Wooton and Standley (Contr. U. S. Nat. Herb. **19**: 135. 1915) give them as 5–8 cm. long, and Trelease (Rep. Missouri Bot. Gard. **13**: 110. 1902) says that they are "about 75 mm." long; these facts would indicate that our large-flowered plants have flowers large for the species. It is to be hoped that future collections will be made with especial attention to this species, in order to ascertain the exact nature and extent of the floral variation here indicated.

In passing, it should be noted that the style-characters given by Trelease (Rep. Missouri Bot. Gard. **13**: 46. 1902; and Contr. U. S. Nat. Herb. **23**: 91. 1920) and the flower- and foliage-characters given by Sargent (Gard. & For. **9**: 104. 1896) seem to be illusionary, and that the distinctness between our western *Y. mohavensis* and the Texan plant originally called *Y. baccata* var. *macrocarpa* (Torrey, *l.c.*) is open to strong doubt. We would use the name *Y. macrocarpa* (Torr.) Coville (Contr. U. S. Nat. Herb. **4**: 202. 1893) in preference to *Y. mohavensis* Sarg., were it not for Engelmann's *Y. macrocarpa* (Bot. Gaz. **6**: 224. 1881); the denotation of *Y. macrocarpa* Engelm. is uncertain from the literature (Trelease, *op. cit.* 98. 1902; Sargent, *l.c.*; and Engelmann, Bot. Gaz. **7**: 17. 1882); and it is thought best to make no change in our usage until it has been definitely decided whether Engelmann's species be a synonym of *Y. Schottii* or actually identical with Torrey's var. *macrocarpa*, as Wooton and Standley have treated it. In other words we use *Y. mohavensis* in a wide sense and include therein *Y. baccata macrocarpa* Torr., though appreciating the fact that *Y. mohavensis* may not be the correct name for such a concept

Dr. Merriam (N. Am. Fauna **7**: *pl. 12, 14.* 1893) has given two plates that show the very different forms which characterize *Y. baccata* and *Y. mohavensis.* Although his plate of the latter represents the dominant and ordinary phase of that species, yet we observed a phase with unbranched trunks and usually longer leaves, whose habit is strongly suggested by the plants of a very different species, figured in *pl. 3* of the third report of the Missouri Botanical Garden.

NAIAS FLEXILIS (Willd.) Rostk. & Schmidt

Caulinia flexilis Willd. Abh. Akad. Berlin 95. 1803.
Naias flexilis Rostk. & Schmidt, Fl. Sedin. 382. 1824.

Previously reported by Davidson from Soldiers' Home near Los Angeles; collected in 1919, *Street & Williams 2688*, at Laguna Lakes near Laguna Beach, about fifty miles southeast of earlier records. The shallow pools known as the Laguna Lakes have a rather interesting lot of aquatic plants, such as *Zannichellia palustris*, *Echinodorus cordifolius*, *Marsilea vestita*, and *Elatine californica*.

ERIOGONUM APICULATUM Wats.

Eriogonum apiculatum Wats. Proc. Am. Acad. **17**: 378. 1882.

This species, said by Jepson (Fl. California 407. 1914) to occur on "Mt. San Jacinto, 7800 to 8200 feet" and on "Cuyamaca Mt.," has been collected at 5,500 feet, August 5, 1918, *Mrs. Mary F. Spencer 989*, in open woods on Palomar Mountain in San Diego County. This station, in addition to being of altitudinal interest, is considerably west of the others mentioned.

MOLLUGO VERTICILLATA L.

Mollugo verticillata L. Sp. Pl. 89. 1753.

Said by Jepson (Fl. California 460. 1914) to be "sparingly naturalized" and given as collected by Davidson in Los Angeles. Abrams (Fl. Los Angeles 127. 1917) names also Laguna in Orange County. We can report this plant from near Beaumont, on the line between Riverside and San Bernardino Counties, *Munz 2614*, March 1919, growing on a dry hillside in the chaparral at about 2000 feet.

HERNIARIA CINEREA DC.

Herniaria cinerea DC. Fl. Fr. Suppl. 375. 1815.

This species, naturalized from southern Europe, can now be reported from Southern California, *Munz & Johnston 4406*, Pomona College Campus, Claremont, where it is fairly well established, but threatened by impending grading and building. Our plants are well matured and some of them had ripened their seeds by the end of March.

ANEMONE TUBEROSA Rydb.

Anemone tuberosa Rydb. Bull. Torrey Club **29**: 151. 1902.

Previously recorded from California as collected in the Panamint Mountains, 1891, *Coville & Funston;* and in 1849 by Fremont,

locality not given. It was found abundant at the eastern base of the Providence Mountains on rocky slopes just below the pinyon belt, *M. & H 3555* and *M, J. & H 4207*.

MYOSURUS CUPULATUS Wats.

Myosurus cupulatus Wats. Proc. Amer. Acad. **17**: 362. 1882.

Canyon side in the Upper Sonoran Zone at 4,000 feet, Providence Mountains, *M, J & H 4152*, May 22, 1920; at this time the plants were quite dead, having matured their seeds. Previously known only from a few collections in Arizona.

JEPSONIA PARRYI (Torr.) Small

Saxifraga Parryi Torr. Bot. Mex. Bound. Surv. 69. *pl. 25*. 1859.
Jepsonia Parryi Small, Bull. Torrey Club **23**: 18. 1896.

In January, 1921, Mr. Gordon Nicholson detected a very populous colony in a small side canyon running up into the Santa Ana Mountains from the Santa Ana Canyon, and very near the Orange-Riverside County line. The plants grew at about 1,000 ft. altitude in clay soil, on a rather open grassy slope facing west. We have only specimens in leaf, but these check closely with plate 25 in the Mexican Boundary Survey Report. The type came from San Diego County where it has been collected several times since, but outside of that county it has been known from but two collections, both in Riverside County. Dr. Hall found it at Double Butte near Winchester, and Mr. Parish has reported it from Palm Springs (Muhlenbergia **3**: 123. 1907).

LINUM SPERGULINUM Gray

Linum spergulinum Gray, Proc. Am. Acad. **7**: 333. 1868.

This plant, previously known from Middle California, has been collected in Pine Hills, San Diego County, *Mrs. Mary Spencer 1596*, at 4,200 ft., on June 25, 1920. The appendage on the petal is as described by Gray.

HOLACANTHA EMORYI Gray

Holacantha Emoryi Gray, Pl. Nov. Thurb. 310. 1855.

Two collections were made: one, *M, J & H 4295*, was eight miles west of Ludlow in a sandy wash along which it occurred for several miles; the other, *M, J & H 4300*, was five miles east of Amboy on flat stony desert. Both these specimens are more

compact than Emory's figures in the Mexican Boundary Survey, but a specimen sent us by Mr. S. B. Parish, collected by a Mr. Childs at the Hayfields in the Chuckawalla Valley, is of more open habit than the one in Emory's plate. Both of our collections were very near the road and from large conspicuous shrubs, three to four feet high, forming wide gray masses of interlacing thorns; it seems strange that such conspicuous plants so near the road have been collected so seldom. Our Ludlow station is no doubt the one reported by Mrs. Ferris (Bull. So. California Acad. **18**: 13. 1919), but the one near Amboy is some distance from those reported by Davidson (*ibid.* **19**: 55. 1920).

TRAGIA RAMOSA Torr.

Tragia ramosa Torr. Ann. Lyc. N. Y. **2**: 245. 1826.

Locally common in a gravelly and stony canyon bottom in the Lower Sonoran Zone at the eastern base of the Providence Mountains, *M, J & H. 4219.* The first collection that has been reported from California.

ABUTILON PARVULUM Gray

Abutilon parvulum Gray. Pl. Wright., **1**: 21. 1852.

In rocky ground at the base of the Providence Mountains near a deserted mining camp several miles south of the Bonanza King Mine; rather common locally; *M, J & H 4206.* First record from California.

FRASERA PARRYI Torr.

Frasera Parryi Torr. Bot. Mex. Bound. Surv. 156. 1859.

Collected June 7, 1919, in the foothills of the San Gabriel Mountains between Live Oak and San Dimas Canyons, by *Mrs. Fitch, C. F. Baker Herbarium No. 6594.* Long ago reported from "east of . . . Los Angeles" by Brewer (Bot. California **1**: 484. 1876), but not again detected on the south slope of the San Gabriel range until the present. Frequent in the San Bernardino and San Jacinto ranges, where it inhabits pine-clad slopes of the Transition Zone. The present collection was a single plant and grew in the lower chaparral belt at about 1700 feet altitude.

SALVIA MOHAVENSIS Greene

Audibertia capitata Gray, Proc. Am. Acad. **7**: 387. 1868.

Salvia mohavensis Greene, Pittonia **2**: 235. 1892.

Collected on the crest of a rocky outlying spur of the Turtle Mts. southwest of Needles, *M & H 3509*. It was also found rather commonly on rocky places in the Providence Mountains, which constitute the type locality. The Parish brothers long ago collected it in the mountains near Camp Cady. The Turtle Mountain station was at only about 1,200 feet altitude; plants were beginning to flower there on the first of April. In the Providence Mountains the species was observed from the base to near the crest, from 3,000 to 7,000 feet altitude, where only a few plants were in bud in the last week in May. Field observation would indicate that the species is restricted to rocky places, paying little attention to the lines between the Sonoran Zones.

CRYPTANTHA MARITIMA Greene

Krynitzkia ramosissima Greene, Bull. Cal. Acad. **1**: 203. Au 1885. Not *Krynitzkia ramosissima* Gray, Proc. Am. Acad. **20**: 277. Ja 1885.

Krynitzkia maritima Greene, Bull. Cal. Acad. **1**: 204. Au 1885.

Cryptantha maritima Greene, Pittonia **1**: 116. 1887.

Attention should be called to the fact that the plants currently going under the name of *C. ramosissima* Greene should properly be designated as *C. maritima*. As Coville indicated twenty-nine years ago (Contr. U. S. Nat. Herb. 4: 165. 1893) *K. ramosissima* is an untenable name for the plant in question, Gray having originally proposed it as a substitute, on the grounds of applicability, for the specific name *racemosa*. Gray clearly indicated that *Eritrichium racemosa* Wats. and *K. ramosissima* Gray were synonymous, but Greene took the latter name and gave it a wholly new connotation, making it cover certain misdetermined specimens cited by Gray under the name *K. ramosissima*. *K. ramosissima* Greene is a redefinition of *K. ramosissima* Gray, and as this latter is unquestionably a synonym of *C. racemosa*, the former, technically having the same type as the latter, since it is merely a redefinition of it, cannot be considered more than an improper interpretation of *K. ramosissima* Gray. Neither the American nor the Vienna Code will justify the use of *K. ramosissima* in the sense that it is currently used in today!

C. maritima was described from Guadalupe Island specimens, but despite its remote insular habitat, like many other species,

it is identical with the mainland form. Gray (in the supplement of the Synoptical Flora, p. 428), attempted to distinguish between the insular plant and *C. ramosissima* Greene, but when applied to a series of any size, his characters utterly fail to divide the two forms and certainly do not segregate the material into anything suggesting geographical lines. Vasey and Rose (Proc. U. S. Nat. Mus. **11**: 532. 1888) and Brandegee (Bot. Gaz. **27**: 453. 1899) have expressed doubts as to the distinctness of *C. ramosissima* and *C. maritima*, but now with a fine series for study, we feel that their doubts can be increased to the point of certainty. Every character presented by the Guadalupe specimens, or for that matter by any of the coastal plants, can be exactly duplicated in specimens from the desert interior. Though it is unfortunate that a name such as "*maritima*" should be applied to a plant so characteristic of the driest portions of the desert area, yet there is no technical reason for coining a new name or for accepting any other old one.

Among the California representatives of the genus, *C. maritima* is unique in its possession of dark reddish stems. This species, along with *C. recurvata*, possesses but two ovules, a condition different from that found in all other species of the genus (*cf.* Brandegee, *l.c.*).

Cryptantha gracilis var. **Hillmanii** (Nels. & Ken.) comb. nov.
Cryptantha Hillmanii Nels. & Ken. Proc. Biol. Soc. Washington **19**: 157. 1906.

This plant must now be accredited a place in the California flora. It would seem that it enters the state only in the region of the Providence Mountains, for the only California collections come from them; Mrs. Brandegee got it at Barnwell and we made a fine collection, *M, J & H 4222*, near the Bonanza King Mine.

C. Hillmanii is very close to *C. gracilis* Osterhout (Bull. Torrey Club **30**: 236. 1903) and at most is but a poor variety of the latter species. Abundant collections of the species may cause *C. Hillmanii* to be reduced outright, but the single isotype of *C. gracilis* in the University of California collection seems to differ from all the specimens of *C. Hillmanii* in its lower and more slender habit and less congested inflorescence; therefore, for the time

being, *C. Hillmanii* can be retained in varietal rank. The type of *C. gracilis* came from Glenwood Springs in the mountains of Colorado and it is entirely possible that the differences detected are environmental in origin. Among California cryptanthas, *C. Hillmanii* can be recognized by its single smooth nutlet and usually fulvous, densely pilose and inconspicuously bristly calyx.

Penstemon Munzii Johnston, sp. nov.

Plants with several coarse, erect, loosely tufted glabrate stems that become at least five dm. high; leaves all opposite, entire and glabrate; basal leaves ovate- or lanceolate-spatulate with winged petioles that about equal the blade, becoming 7 cm. long and 2.5 cm. wide; the lower cauline leaves oblanceolate, the upper ones broadly sessile and lanceolate, while the leaves of the inflorescence are minute and linear-subulate; inflorescence narrow, the flowers in strict one- to three-flowered cymules; corolla bright red, 2 cm. long, narrowly funnelform-tubular, evenly though but slightly ampliated upward, strongly and conspicuously bilabiate, glabrous within; upper two lobes of the corolla erect, about 7 mm. long, united for about two-thirds of their length, lower three lobes of the corolla strongly reflexed, about 6 mm. long, united for nearly half their length; anther-sacs glabrous, obscurely rugulose or papillose, adnate if at all only near the base, ovate-oblong, 2–2.5 mm. long, their inner sides paralleling each other or forming a small angle; dehiscent by a slit extending between two-thirds and three-fourths the way to the base, sharply dentate along the line of dehiscence; sterile filament glabrous, somewhat flattened, emarginate; sepals broadly ovate, acute, 3–5 mm. long, scarious margined; pedicels about as long as the sepals; fruit unknown.

Known only from the type specimen, collected in May, 1920, *Munz, Johnston, & Harwood 4271*, on a high exposed ridge in the pinyon belt near the Bonanza King Mine on the east slope of the Providence Mountains, Southeastern California. The type is No. 7534 in the Baker Herbarium of Pomona College.

Certainly of the *Barbati* and probably nearest *P. barbatus Torreyi* (Benth.) Gray, but very different from it in its color, which is a brighter, lighter, and more yellowish red, in the measurements of the corolla, and in the size as well as non-divergence of the anther-sacs. *P. Munzii* is a lower, stouter, and less graceful plant than most of the forms of *P. barbatus* (Cav.) Roth.

From *P. Eatoni* Gray and from *P. subulatus* Jones, the other two red penstemons found in this part of the desert area, both of

which are in the *Centranthifolii*, this species can be quickly separated by its unique tone of red and by its smaller, stouter, decidedly bilabiate corollas. It is a well marked species and a fitting addition to the interesting penstemon flora of the Providence Mountains.

Penstemon Clevelandii var. **Stephensi** (Brandegee) comb. nov.
Penstemon Stephensi Brandegee, Zoe **5**: 151. 1903.

During one of our trips to the Providence Mountains we made a small collection of this little known plant, which is apparently rare in the type region; for Mr. Brandegee informs us that he collected only enough for the type sheet, a full one, while our collection, *M, J & H 4274*, was enough for only a few duplicates.

A critical study of our collection and of the type seems to indicate that *P. Stephensi* finds a very close relative in *P. Clevelandi* Gray, a species restricted to the canyons about the Colorado Desert and in the mountains to the west of it. Our collection of *P. Stephensi*, as well as the type, is so similar to certain collections of *P. Clevelandi* (*e.g.*, *Hall 1160* and *2149* and *Parish Bros. 1216*) that as far as gross aspect, size and vegetative characters are concerned, they might be of one and the same collection. There is, however, one character which separates the two collections of *P. Stephensi* from all of the many collections of *P. Clevelandi;* this is the lack of bearding on the sterile filament. Though the corollas of the two forms are alike in size, color, and shape, the sterile filament in *P. Stephensi* is absolutely bald, while it is densely bearded in *P. Clevelandi*. Appreciating, therefore, that we are concerned here only with a unit-difference, we feel that *P. Stephensi* is nothing but a geographic race of *P. Clevelandi* and, because of it, worthy only of a subordinate rank.

PENSTEMON PALMERI Gray

Penstemon Palmeri Gray, Proc. Am. Acad. **7**: 379. 1868.

We found this species to be the most common and most spectacular penstemon in the Providence Mountains, *M, J & H. 4276*. About the Bonanza King Mine it was common about the foot of the mountains and especially so in small draws, where it grew in large colonies. This being our first acquaintance in the

field with the typical plant, and knowing quite intimately the low, much-branched, few-flowered montane plant, currently going under the name of *P. Palmeri*, we were much surprised to discover that this tall, virgate, many-flowered, desert plant was the typical form of *P. Palmeri*. While unquestionably, the montane plant is a close ally of the taller interior form, and as herbarium material shows, intergrades with it, yet we feel that so pronounced an extreme ought to be given nomenclatorial recognition, and so, for us, the mountain form becomes:

Penstemon Palmeri var. **Grinnellii** (Eastw.) comb. nov.

Penstemon Grinnellii Eastw. Bull. Torrey Club **32**: 207. 1905.

The type of this form came from Mt. Wilson and is the form rather common in rocky ground in the pine belt, and to a less extent in the upper chaparral belt, in the mountains of Southern California from the San Jacinto Range northward. With this restriction the species itself becomes strictly deserticolous. In its extreme the variety is characterized by its looser, shorter and fewer flowered inflorescence, lower and more slender stature and non-glaucous leaves.

PENSTEMON CALCAREUS Brandegee

Penstemon calcareus Brandegee, Zoe **5**: 152. 1903. Not Jones, 1908.

Penstemon desertorum Jones, Contr. W. Bot. **12**: 59. 1908.

We succeeded in making a fair-sized collection of this peculiar and interesting little plant, *M, J & H. 4154*. The species is known from but two other collections, all of them from the Providence Mountains, where it grows in crevices of rocks on vertical cliffs.

P. desertorum Jones, the type of which came from Kelso on the west slope of the mountains, is identical with Mr. Brandegee's species; for isotypes of the former plant are exact matches for plants on the type sheet of the latter; in fact, Mr. Brandegee's type, Mr. Jones' Kelso collection and our plants form a remarkably uniform series in aspect and size, as well as in structural characters.

P. calcareus Jones (Contr. W. Bot. **12**: 60. 1908) is a homonym and appears to be a synonym of *P. petiolatus* Brandegee (Bot. Gaz. **27**: 455. 1899).

Penstemon antirrhinoides var. **microphyllus** (Gray) comb. nov.
Penstemon microphyllus Gray, Pac. R. R. Rep. 4: 119. 1856.
Penstemon Plummerae Abrams, Bull. Torrey Club 33: 445. 1906.

In California this interior form of *P. antirrhinoides* Benth. is known only from the Providence Mountains. Mr. Brandegee collected and reported it (Zoe 5: 151. 1903) as *P. antirrhinoides*, while we found it to be rather common on the rocky sides of a small canyon back of the Bonanza King Mine. Although quite familiar with *P. antirrhinoides*, as represented on the coastal slopes, we could not detect in this desert plant any peculiarities of habit or size, though while observing the plant in the field we agreed that there was some intangible difference, a difference which was later discovered to reside in the grayish hue resulting from a cinereous pubescence.

This shrub was described by Gray from flowerless specimens collected by Bigelow on the "Williams Fork of the Colorado." Based on insufficient material, the plant has remained an obscure one. It is not surprising, therefore, that Dr. Abrams, upon meeting so obscure a plant, treated it as though it were undescribed. It can hardly be doubted that *P. Plummerae* and *P. microphyllus* are synonyms, for Dr. Gray's meager description applies completely to *P. Plummerae*, while the types of both are from the same phytogeographical area. Significant evidence is found also in the fact that this is the only shrubby *Penstemon* revealed by recent collecting in Arizona.

Dr. Abrams has indicated the characters separating this form from the typical *P. antirrhinoides*, which ranges on the hillsides near the coast from San Pedro Martir Mountains northward to near San Bernardino, and which is characterized by its very broadly ovate sepals and glabrate or puberulent twigs. The variety *microphyllus*, on the other hand, is strictly an interior form, ranging from the Providence Mountains eastward into western Arizona, and is marked by its distinctly cinereous twigs and oblong-ovate or ovate-lanceolate sepals. While the threefold difference residing in the sepals, pubescence and range, argues much for specific distinctness of these plants, the relationship is so close and so obvious that we feel it best to treat them only as well marked geographic forms.

PENSTEMON ALBOMARGINATUS Jones

Penstemon albomarginatus Jones, Contr. W. Bot. 12:61. 1908.

We are able to report the first collection in California of this distinct species. We obtained the plant near Lavic, where it grew in the deep sand of a wash that ran up between the tongues of the lava-flow surrounding Mt. Pisgah. The wash was a stone's throw from the Sante Fe Trail and near the grade crossing west of Lavic. The species is very aptly named, for the white margining to the leaves and sepals is very striking. It is apparently rare and we can get trace of but three other collections: Good Springs, Nevada, and Yucca, Arizona, reported by Professor Jones; and Jean Station, Nevada, collectcd by Mrs. Brandegee (specimen in the herbarium of the University of California). Professor Jones collected the type in sand and, as our plant grew in similar material, the species is probably arenicolous and is to be looked for in sandy places. The type and our collection, *M, J & H 4204*, were both collected in May and were at the time setting seed.

Aplopappus Gooddingi (Nels.) comb. nov.

Sideranthus Gooddingi Nels. Bot. Gaz. 37: 266. 1904.

A single plant, *M & H 3603*, collected on a gravelly hillside about eleven miles west of Needles. The present collection is the first one from California, but is remarkably like the typical plants from Nevada. It is characterized by its perennial root and tall strict stems and large and multiradiate heads, which are up to 16 mm. wide. *A. gracilis* the nearest relative of the desert regions, is a lower annual with ascending stems, smaller (1 cm. or less wide) heads and fewer rays, eight to sixteen; its leaves are more setose than in *A. Gooddingi.*

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INDEX TO AMERICAN BOTANICAL LITERATURE

1910–1921

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Vol. 49 No. 3

BULLETIN

OF THE

TORREY BOTANICAL CLUB

MARCH, 1922

Quadripartition by furrowing in Sisyrinchium

CLIFFORD H. FARR

(WITH PLATE 2)

Since the publication of the author's paper (5) on *Magnolia* there have appeared a few contributions to the subject of the quadripartition of pollen-mother-cells by furrowing. In 1918 Täckholm and Söderberg (24) presented an interesting discovery of the occurrence of quadripartition and bipartition respectively in two species of *Aristolochia*, a genus of Dicotyledons; *Aristolochia fimbriata* was found to have successive bipartition, just as Samuelson (19) had reported in this genus, but *Aristolochia Sipho* was found to have quadripartition of the pollen-mother-cells after the homoeotypic mitosis. It is stated that there is a slight thickening of the spindle fibers after the heterotypic division in the latter species, but no figures of quadripartition are shown in this paper. In *Vinca rosea* the authors conclude that quadripartition must occur because of the tetrahedral arrangement of the microspores within the mother wall. It will be remembered that Frye and Blodgett in 1905 (8) found successive bipartition in the sister genus *Apocynum*, and the microspores here are sometimes arranged tetrahedrally. The authors (24) state that after the homoeotypic division in *Aristolochia Sipho* walls are laid down as fine plates on the equator of the spindle, and that in *Albizzia lophanta*, a Dicotyledon, and *Dioscorea quinquefolia*, a Monocotyledon, quadripartition

[The BULLETIN for February (49: 31–50) was issued April 4, 1922.]

is accomplished by equatorial plates on the spindles. Quadripartition by cell-plates has never been satisfactorially described and figured in any of the higher plants in connection with a study employing modern methods of microtechnique; it is therefore much to be desired that the authors present these instances in detail as soon as possible.

Florin (7) in 1918 found that quadripartition occurs in the spore-formation of one of the acrogynous Jungermanniales but does not give the details of the process as to whether it is by furrowing or cell-plates. In 1919, Miss Digby (3) published an extensive chromosomal study of *Osmunda* in which she refers to the formation of cell-plates after the first reduction division. These apparently persist through the second mitosis without forming completed partitions, and then other cell-plates are formed at right angles to these. The figures of these stages are drawn from material of *O. palustris* var. *aurea* although the description seems to apply to all four of the types studied, including *O. regalis*. Smith (20) in 1900 described and figured these stages of the latter species. He concluded that the cell-plate of the first division was ephemeral and that the division was finally accomplished by the simultaneous formation of six cell-plates on the six spindles respectively, thus accomplishing quadripartition by cell-plates. During 1920 Yamaha (27) published a study of cell-plate formation in the archesporial and spore-mother-cells of *Psilotum triquetrum*. He found that the nearly complete cell-plate which is formed after the first meiotic division breaks up into a granular mass, which persists until the close of the second nuclear division. At this time it becomes transformed into connecting fibers upon which a cell-plate is laid down between the non-sister nuclei, while other cell-plates are being formed on the connecting fibers between the sister nuclei of the second division. In this way a quadripartition of the cell is accomplished by cell-plates. Yamaha concludes that the cell-plate has a duplex nature from the first, and that it does not split after formation as Timberlake believed. It is to be noted that in quadripartition by furrowing the partition is duplex from the first. Yamaha suggests that the invagination of the plasma-membrane may play some part in the later stages in these cells of *Psilotum*. It therefore seems to me that on account of this duplex nature of the partition and in the light of the recent work on quadriparition by furrowing that further work on cell-division of *Psilotum* would be warranted.

Guérin (10) has made a study of the development of the anthers and pollen of the labiates, but passes over the matter of division of the mother-cell into the four microspores as exhibiting nothing of particular interest. Valleau (26) in connection with his study of sterility in the strawberry has published a careful account of pollen-formation. He describes in detail the formation of the material about the protoplast which in other forms has been considered as the thickening of the cell-wall. However, in *Fragaria,* it seems to be a secretion from the protoplast rather than the thickening of the wall. With regard to the formation of the partitions the author does not commit himself. He states:

> The daughter nuclei are soon formed, and walls are laid down between them, dividing the cytoplasm evenly. The cells gradually split apart, separating the four microspores and allowing the entrance between them of the viscous material.

It might be concluded from this description that cell-plates accomplish the partitioning and that the invagination of the peripheral material is simply incidental to the rounding up process. No figures of these stages are shown. Quite recently R. R. Gates (9) has published a preliminary account of reduction divisions in the pollen-mother-cells of *Lactuca sativa.* In this paper there is described a quadripartition by furrowing rather than by cell-plates, just as the writer (4) had previously reported for *Helianthus* and *Ambrosia,* as well as in other groups of Dicotyledons. No drawings are given by Gates, but a paragraph is devoted to a description of the process. He mentions that furrows may be formed either in the presence or the absence of spindle fibers but does not describe the latter instance any farther. It is stated that an ephemeral cell-plate occasionally is found after the heterotypic division, but it never functions and no cell-plate is present after the homoeotypic mitosis.

The most careful recent study of this question is that of Mrs. Wanda K. Farr (6), in which she gives figures and descriptions of quadripartition in the pollen-mother-cells of *Cobaea scandens.* These support the writer's contention (4) that cell-division by furrowing is common in the pollen-mother-cells of Dicotyledons. It is interesting to note that the first description of cell-division in any plant is probably that by Brongniart in 1827 on the pollen-mother-cells of *Cobaea scandens* (2), in which it is indicated that the process is furrowing, though, of

course, he had no realization of the internal mechanism of the cell. This work was followed by that of Mirbel (17) who presented his paper in 1832, though it was not published until later. He described and figured quadripartition by furrowing in the pollen-mother-cells of *Cucurbita Pepo.* A little later Von Mohl (18) published figures and descriptions of the same process in other plants. It now seems that the interpretation given by these first observers was more nearly correct than that which has been given by most students of cell-division in higher plants in more recent years.

Up to the present no detailed study has been made of quadripartition in Monocotyledons, and it was with the idea of comparing the situation in this group with that found in Dicotyledons that the present study was undertaken. Several cases of quadripartition in Monocotyledons are known. In 1915, L. Guignard published two papers (12, 13) on the occurrence of quadripartition in Monocotyledons. In the first paper he includes a comprehensive review of the literature on that subject, as well as on bipartition in the reduction-divisions of Dicotyledons. Quadripartition in Monocotyledons and bipartition in Dicotyledons at the time of reduction-divisions are unquestionably the exception in the method of pollen formation in these two groups respectively. So rare is their occurrence in fact that Van Tieghem (25) used them as characters of prime importance in distinguishing the two classes of Angiosperms, thereby including the Nympheaceae with the Monocotyledons. Guignard had previously (11) reported quadripartition in six genera of the Orchidaceae, and in the first (12) of his recent publications adds four genera (six species) of Liliaceae and six genera (sixteen species) of the Iridaceae. To this list the second paper (13) contributes three more genera (three species) to the number of the Iridaceae having this method. To the Liliaceae may be added Strasburger's (21, p. 151) findings in *Asphodelus*, and it will be remembered that Hofmeister found it in *Naias* (14, p. 636). In 1917, Täckholm and Söderberg published a paper (23) in which they discuss tetrad formation in Monocotyledons. In addition to its occurrence in the above-mentioned groups they refer to quadripartition being reported by Hofmeister in *Tradescantia*, by Rosenberg in *Anthericum* and by Von Mohl and others in the Juncaceae. So that they find it reported in six families of the Monocotyledons, namely: Liliaceae, Juncaceae, Iridacaea,

Commelinaceae, Orchidaceae, and Cyperaceae. The last-named is included because of the work of Juel on *Carex*, of which it it may be questioned whether the term quadripartition is applicable. In 1918 the same authors (24) published again, adding another species of Monocotyledons to this list, namely, *Dioscorea quinquefolia*. This brings the total number of genera up to nineteen or twenty. In *Canna* they report a tetrahadral arrangement of the microspores but do not take this as evidence of quadripartition.

Guignard (12) states that in four species of *Iris* there is occasionally a suggestion of a partition after the heterotypic nuclear division but this is always ephemeral. After the homoeotypic mitosis in *Sisyrinchium*, *Antholyza*, *Freesia*, *Ixia*, and *Monbretia*, when the fibers of the central spindle are formed between the four nuclei, it is stated that rather frequently there is noticeable a faint thickening on the internal face of the mother wall at the places which are to become the points of insertion of the partitions. Further than this no details of quadripartition are given, nor are drawings or photomicrographs shown to give evidence as to whether the process is accomplished by cell-plates or by constriction furrows. It is not unlikely that the ephemeral equatorial differentiations which Guignard found in these Iridaceae, and which Täckholm and Söderbeg reported for *Aristolochia Sipho* are orange zones, such as the writer (5) has shown to occur in *Magnolia*. Täckholm and Söderberg (24) do not describe the process of quadripartition in *Dioscorea* except to state that it is accomplished by equatorial plates being formed on the spindles.

It thus appears desirable that a study be made of the details of the process of quadripartition in a Monocotyledon. The writer has discussed at some length the literature on this subject in his first paper in 1916 (4). At that time he presented a description and drawings of quadripartition in *Nicotiana* and other Dicotyledons which led to the conclusion that no cell-plates are formed, but that division is accomplished by furrows very much as in animal cells. Mrs. Wanda K. Farr (6) has more recently shown that the same type of cytokinesis occurs in *Cobaea scandens* as was found in *Nicotiana*. In 1918, the writer (5) supplemented the work of Guignard on *Magnolia*, in which the latter showed incipient furrows during interkinesis, but did not present the stages following the origin of the tetranuclear

condition. It was found that after the disappearance of the ephemeral orange zone a furrow developed on the margin of the equator of the heterotypic spindle. However, the development of this furrow is arrested when it is only about one-fourth completed and the homoeotypic nuclear division ensues. The division of the cell is finally accomplished by the completion of this furrow and the formation of two other furrows at approximately right angles to it. Although *Nymphaea* has not as yet been thoroughly investigated the work of Lubimenko and Maige (16) indicates that it is similar in this respect to *Magnolia*.

The following study was made upon material of *Sisyrinchium Bushii* Bicknell, collected near College Station, Texas, and identified by Dr. A. S. Hitchcock. This species proved especially fine for study, both because of the excellent fixation and because of the distribution of the mitotic figures in the anthers. In *Nicotiana* the mother-cells of a given anther are all in very nearly the same stage of division, and hence to secure an unbroken series of stages it is necessary to take material from several different anthers. In *Magnolia* the mother-cells within the anther were at different stages but there was no special arrangement of them. In either of these cases the objection might be raised that a cell-plate was overlooked due to the study of an incomplete series of stages. It was therefore highly desirable that a form be found in which the stages were arranged in order within the anther from one end to the other, so that by studying a number of anthers it could be determined with certainty that no steps have been omitted. Such a situation is that which *Sisyrinchium Bushii* presents. The mother-cells at one end of the anther may be in metaphase of the heterotypic division and those at the other end in metaphase of the homoeotypic. This is the condition shown in FIG. 1. In FIG. 2, the cells at the inner end are in metaphase of the homoeotypic division and those at the outer end are in the tetranuclear stage. It is evident that the study of a number of such anthers is sure to reveal every stage, however transitory. It will be remembered that a similar condition exists in the testes of *Batracoceps*, and among plants it was found by Strasburger (22) in the anthers of *Fritillaria* and by D'Angremond (1) in the banana.

The pollen-mother-cells of *Sisyrinchium* are smaller than those characteristic of many Monocotyledons. Miss Klieneberger (15) has recently published a study of the size of nuclei

of Monocotyledons, in which she finds that contrary to the general opinion the nuclei of most Monocotyledons are small. It is only in the Iridaceae and parts of the Liliaceae, Amaryllidaceae and Convallariaceae that large nuclei are found. However, her study is not concerned with pollen-mother-cells especially. It would be interesting to find how great the differences in size of pollen-mother-cells may be among Monocotyledons, and their relation to the size of the nuclei. The tetranucleate pollen-mother-cells of *Sisyrinchium* just before division are 36–40 microns in diameter, which is just about the size of those of *Nicotiana*.

The mother-cell wall is likewise thickened to about the same extent as is that of *Nicotiana*, that is, on the average about one-tenth of the diameter of the cell. The process of thickening of the cell-wall begins about the time of synapsis, but the greatest development is during interkinesis. The cells are more compact within the anther than they are in either *Nicotiana* or *Magnolia*, but nevertheless are quite loosely disposed during diakinesis and later stages of reduction. They are somewhat closer together toward the end of the process than in the earlier stages doubtless due to the enlargement of the cells and the thickening of the walls. There seems to be no evidence that the gelatinous substance enveloping the protoplast during the later stages of reduction-divisions is a secretion from the protoplast, as Valleau (26) suggests, rather than a product of the cell-wall. The middle lamellae remain quite distinct throughout these stages and careful observation of the material both of *Sisyrinchium* and of the other forms previously studied leads the writer to the conclusion that it is the secondary lamellae of these pollen-mother-cells which during reduction-divisions take on the colloidal property of imbibition and swell to many times their original thickness.

The heterotypic division results in two discoid nuclei being organized at opposite ends of a rather long central spindle. No indication of a cell-plate or other equatorial differentiation is to be discerned at any time during interkinesis. Nor is there any indication of furrowing. The nuclei gradually become more nearly spherical (FIG. 1) and finally, before the second nuclear division begins, they are almost perfect spheres. They apparently do not come into contact with the plasma membrane. The fibers of the central spindle disappear almost entirely during in-

terkinesis, and the integrity of the spindle as such becomes entirely lost. The fact that all stages of interkinesis may be found within the extent of a single anther (FIG. 1) makes it possible to arrive at an index of the relative time required for that stage. Judging from the extent of the various stages within the anther it would seem that the time involved in interkinesis is about equal to that involved in either the first or the second reduction-division.

In the metaphase of the homoeotypic nuclear division the spindles are in some cases parallel and in some at right angles to each other, and in still others at positions intermediate between these two extremes. When the nuclei are reconstituted they may occasionally be found in a single plane as is shown in the outer end of the anther in FIG. 2. But more frequently the nuclei are tetrahedrally arranged (FIG. 3). Quite a number of cells show intermediate orientations. It is interesting to note that the type of division of the cell is the same, regardless of the orientation of the nuclei, just as was previously reported for *Magnolia* (**5**).

The nuclei become reorganized in much the same manner as after the heterotypic division. They, however, do not become as large as in the previous division and they move apart so that they become closely appressed to the plasma membrane. Almost as soon as the nuclear membranes appear spindles are organized connecting the nuclei which are not already connected by the two homoeotypic spindles. There are thus six spindles in all within the cell, but the integrity of some of these seems almost lost especially in cases where the four nuclei are in one plane.

The time elasping between the conclusion of nuclear division and the beginning of cytokinesis is evidently relatively long. This is indicated by the fact that all of the cells of a single anther may be in these stages, those at one end just coming out of karyokinesis and those at the other end not yet showing signs of the formation of partitions. It thus appears that this period is at least as long as that involved in either the heterotypic or homoeotypic mitosis; which is quite in harmony with the writer's previous suggestion (**5**) that cell-plate formation and furrowing do not occur at corresponding periods in the cell-cycle, but that cell-plate formation follows very soon after nuclear division, if indeed the two processes may not frequently overlap. Furrow-

ing on the other hand takes place only after a considerable time has elasped following the re-formation of the nuclei. If cell-plates appeared in this division we would most certainly expect to find them in such an anther as that shown in FIG. 2, but none such are present.

The process of cytokinesis in the quadripartition of the pollen-mother-cells of *Sisyrinchium* is by furrowing and is practically identical with that found in *Nicotiana*. It does not seem necessary to repeat the details of the description of the process here, inasmuch as there is no difference from that which has been published before (4). In cells where the nuclei are tetrahedrally arranged the plasma membrane invaginates most rapidly at the points equidistant from the three nuclei and therefore a central triangular area is formed (FIG. 3). In cells in which the nuclei are in one plane no such central triangular area appears, but the spindles have the same relation to each other, as was shown in those cells of *Magnolia* (5) in which the arrangement was of this type.

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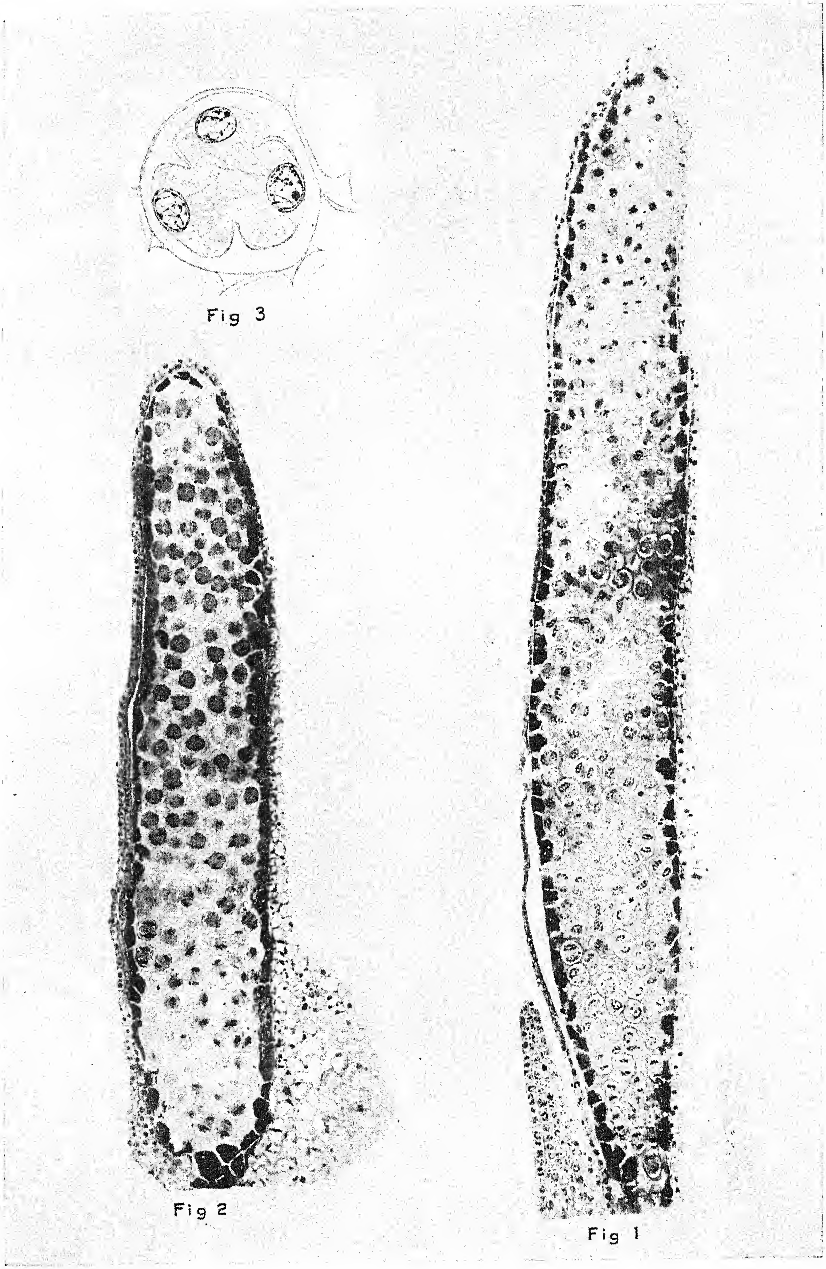
Description of plate 2

FIG. 1. Photomicrograph of a longitudinal section of an anther of *Sisyrinchium Bushii*. The cells in the outer end are in the metaphase of the heterotypic and those at the inner end are in metaphase of the homoeotypic division.

FIG. 2. Photomicrograph of an anther at a slightly later stage of development. The cells at the inner end are in metaphase of the homoeotypic mitosis and those at the outer end are in the tetranucleate stage just prior to furrow formation.

FIG. 3. A drawing of a cell in cytokinesis. The furrows are partly formed and the central triangular area is appearing.



FARR: QUADRIPARTITION IN SISYRINCHIUM

A modern plant fossil

Eda M. Round

(WITH ONE TEXT FIGURE)

While collecting botanical materials in East Killingly, Connecticut, the writer came upon a so-called "cedar swamp" in which ferns like *Woodwardia angustifolia* Smith and *Aspidium simulatum* Davenp. grew, together with sphagnum and several species of liverwort. Woodsmen had visited the locality recently and cut the large hemlock trees, from the stumps of which broad shelf fungi belonging to the Polyporaceae had developed. One of these fungi had been removed from its host by a previous visitor and thrown upon a rock, over which flowed the waters of the peat bog. Examination of this, water-soaked specimen showed it to be tough and pliable like India rubber, due perhaps to the resinous nature of the hemlock tree on which the fungus grew and the preservative qualities of the water from the peat bog. The specimen was in such good condition that the writer contemplated drying it for further study, when a cluster of the same fungi was found *in situ* upon a large hemlock stump, somewhat overgrown by small black birch trees. Examination of one of these specimens revealed not only the ordinary lines upon its surface but also several very clear tracings of black birch leaves, the details of which were as exact as obtain on many rocks with fossil leaves impressed thereon (Fig. 1).

In searching for an explanation of this phenomenon, it appeared that the black birch leaves had touched the surface of the shelf fungus when it was damp and growing rapidly, so that the leaves had been completely overgrown by the fungoid strands while still attached to the parent plant. Over the whole surface could be found examples of leaves in process of being absorbed or incorporated into the fungus, parts of them being encrusted while other parts of the same leaves were free, dry and easily broken. Still other cases showed leaves scarcely touching the fungus but evidently somewhat invaded by its hyphae, as they were beginning to brown and seemed to be dying.

Many ideas are advanced to account for the formation

of fossils.* Given, however, materials of as tough a nature as the shelf fungus from the hemlock stump, on which a leaf had been encrusted or replaced by hyphae of the same tough-

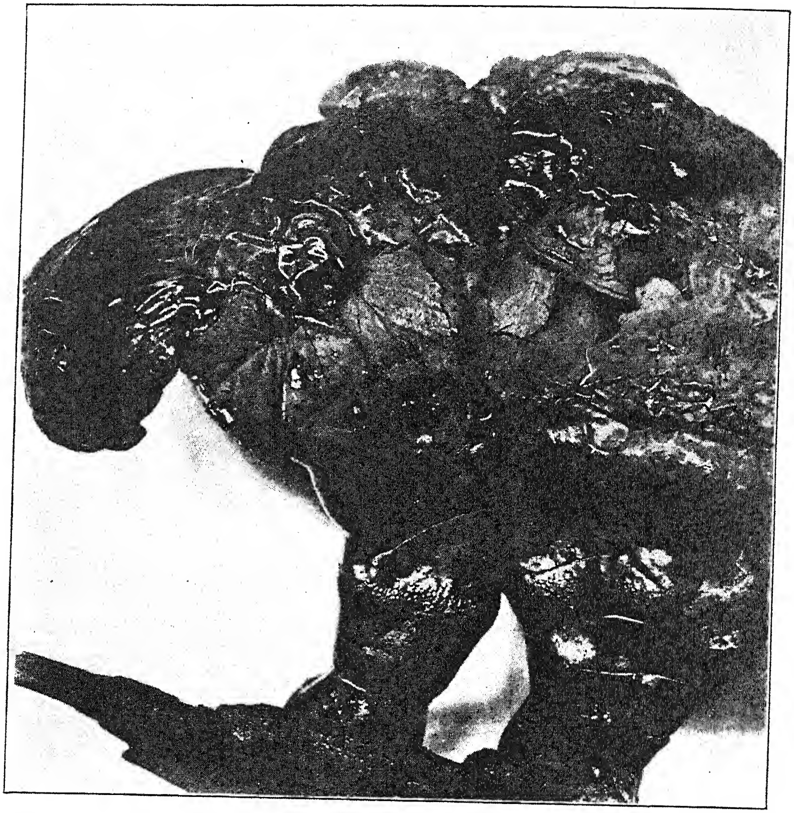


FIG. 1. Black birch leaves "fossilized" on a shelf fungus, × ¾. Original specimen now in the Paleontological Laboratory, Brown University.

ness, one has but to postulate the submergence of the fungus in the surrounding peat bog and conditions are supposedly right for its continued preservation.†

It appears, therefore, that the fungus above described with its encrusted black birch leaves illustrates a method whereby fossils may have formed in the past or may develop under modern conditions. It may therefore be popularly designated as exemplifying a "modern plant fossil."

* Pirsson & Schuchert, Text book of geology, p. 435, 1915.

† See Shimer, An introduction to the study of fossils, p. 3, 1918.

INDEX TO AMERICAN BOTANICAL LITERATURE
1910-1921

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to foresty, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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BULLETIN

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The phylogeny of the genus Brachiomonas

TRACY E. HAZEN

(WITH PLATES 3 AND 4 AND FIVE TEXT FIGURES)

Brachiomonas, one of the oddest and most interesting genera of the *Chlamydomonas* group, has not until now been reported outside of western Europe. The genus was established by Bohlin (**1**) in 1898 with two species, differing in details of form, found in Sweden near Stockholm. The more slender species, *B. gracilis*, has not been reported elsewhere. The type species, *B. submarina*, had been collected about three years earlier by Lagerheim (**6**, p. 7) near Tromsø, Norway, and recorded as a *nomen nudum* which was taken up by Bohlin. A somewhat general distribution of this species on the Norwegian coast has been indicated by Wille (**15**) and Printz (**8**, p. 21). It appears that Dangeard (**3**, p. 74) had observed the same form about ten years earlier than Bohlin, at Luc-sur-Mer, France, but had postponed publishing it until gametes could be found. Chodat (**2**, p. 143, *f. 66*) has recorded the species from Ajaccio, Corsica, showing that it is not exclusively of northern habitat.

West (**12**) in 1908 reported a form collected in brackish marshes at Sheerness, England, near the mouth of the Thames, which he rather hesitatingly referred to *B. submarina*, since it seemed to be somewhat intermediate between Bohlin's two species. In July, 1920, at Cullercoats, near Newcastle-upon-Tyne, and in August at Plymouth, England, I found abundant material in small rock pools, showing forms similar to those described by West, together with specimens agreeing more with Bohlin's type. Earlier in the same season (June 25) I had found on the coast of Norway at Valdersund, near Trondhjem,

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a few specimens which showed precise gareement with Bohlin's description of *B. submarina*. Again a few days later, at Aalesund, south of Trondhjem, I collected typical material, and here in great abundance. At this station some pools were almost exclusively filled with slender forms corresponding to Bohlin's *B. gracilis*; in other pools a mixture of the two species, with perplexing intermediate forms, appeared. Observing pools containing a natural pure culture, one would scarcely question the distinctness of the two species: when both were found together in the same pool, the variety of forms seen presented a very strong suggestion of hybridization between the two species. New material collected in New York in March and April, 1921, has furnished forms (FIGS. 5–7) almost precisely like the slender cells illustrated by West, together with others showing every gradation to the broadest type of *B. submarina*. These slender forms closely resemble Bohlin's *f. 1b* of *B. gracilis*, but I am now convinced that West was entirely justified in including them in the very variable broader species. We seem not to have in America, and I did not find in England the extreme forms represented by Bohlin's *f. 1a* and *1c* of *B. gracilis*. Whether they are sufficiently distinct to warrant the maintenance of the second species is a question which would be more convincingly settled through studies by pure culture methods.

I first found *Brachiomonas submarina* in March, 1907, in a small rock pool on the shore of Long Island Sound at Twin Island, Pelham Bay, New York. It was found in almost pure culture, coloring the water green from its abundance, and persisted in the motile condition for some weeks when brought to the laboratory. Although the same station was visited many times during the following twelve years, no *Brachiomonas* was found until the middle of November, 1919, when it was again abundant in the same pool, and occurred sparingly in neighboring rock hollows of similar character. I found it repeatedly in the same pools until the first of December, in spite of hard frosts and ice formation during these two weeks. The habitat appears to be very like that of Bohlin's type station, small hollows so high above ordinary tide limits as to seem to be filled only with rain water, which are nevertheless sometimes dashed by waves so as to become brackish, as evidenced by taste and by the salt incrustation left on the rock margin upon evaporation. About the time of the collection in 1919, an unusually high tide was reported, and it is possible that this may have washed the

Brachiomonas into the pool from the open sea. Such an occurrence might account for the sporadic appearance of the species at this station, though it is much more probable that it is usually present in a resting state and that conditions were not favorable for the production of zoospores at the time of other visits to the station. A strange point is that, although careful examination of the specimens collected in the spring of 1907 shows them all to be like Bohlin's type, as were also the few specimens found there in September, 1920, and abundant material from March to June and in September, 1921, only a few such individuals were found in the fall of 1919 (FIGS. 1, 2), while most of the material showed a distinct difference in form (FIGS. 8–16). This can hardly be interpreted as a mere seasonal variation. New material collected the last of February of the present season, from pools still coated with ice, consisted very largely of the new obtuse form, but after a week or more in the laboratory this form had mostly been replaced by individuals corresponding to Bohlin's type, present only in small numbers at the time of collection. Whether this is a case of the new type actually giving rise to the standard type through reproduction, or merely an example of the regular succession of growth of different organisms familiar in collections of protozoa, is a matter calling for more extended observation. For the determination of the permanent status of the new form, pure culture methods are highly desirable, but thus far I have been unable to grow *Brachiomonas* on seawater agar, which succeeds admirably with other chlamydomonads of similar habitat. For the present it will be convenient to discuss this divergent plant under the name

BRACHIOMONAS SUBMARINA Bohlin, forma **obtusa** f. nov.

This new form is entirely like Bohlin's type in its genera shape; that is, it possesses a long posterior extension or horn and four shorter median arms directed backwards, often with depressions between them; the anterior portion might be roughly likened to the shape of an umbrella with four ribs. There is often a wedge-shaped beak through which the cilia emerge, though sometimes the apex appears merely rounded. The protoplast may fill the arms and posterior horn entirely (FIG. 8) or partially (FIG. 12) or not at all. The massive chromatophore may be equally variable; that is the protoplasm in the horn and in the arms may be all green, as also in the typical form (FIG. 2), or it may be colorless, sometimes appearing sharply

delimited from the central green mass (FIG. 8), while in other cases the green and colorless regions merge into one another almost imperceptibly (FIG. 1). The chromatophore is here certainly less definitely or constantly organized than in most species of *Chlamydomonas*; in fact it would perhaps be more accurate not to speak of a definite chromatophore but merely of cytoplasm with chlorophyll more or less diffused through it. This variability in the extent of the distribution of the chlorophyll in the protoplasm is very similar to the condition in *Hydrodictyon*, to which Harper (**5**, p. 179) has called attention. West (**12**) states that in his specimens of *B. submarina* the chromatophore never extended into the arms. This was undoubtedly due to the fact that he never saw his material when freshly collected, but only after it had been sent from near the mouth of the Thames to Birmingham. I find that very generally in freshly collected specimens the chromatophore fills the arms and posterior horn, but often retracts from them soon after being subjected to the less favorable light and aeration conditions of captivity.

Imbedded in the chromatophore in a subparietal position, regularly on the side next to the stigma, is a single relatively large pyrenoid; in vigorous young specimens this is generally situated in front of the middle of the cell; often in older individuals it becomes posterior in position. The conspicuous red eye-spot is linear in form; or, sometimes at least, it may be very narrowly wedge-shaped, pointed in front and broader behind; it lies in the depression midway between two arms. Most frequently when the cell is at rest the pyrenoid and stigma lie in a median ventral position (FIG. 6). On the other side of the cell from the pyrenoid the nucleus may sometimes be detected without staining, lying in a colorless mass of cytoplasm, best seen in polar view (FIG. 13). When the pyrenoid lies in its characteristic anterior position the nucleus is likely to be somewhat posterior (FIGS. 15, 17); if the pyrenoid becomes posterior the nucleus is then more often median in position. In older stages vacuoles often develop in the chromatophore (FIG. 4) as described by West (**12**).

In hanging drop cultures, or in jars kept for some time in the laboratory, many individuals may be found which show little or no trace of the four lateral arms (FIGS. 14, 15). Bohlin has shown such a form in one dividing individual. The cell wall is of so firm a character that it is difficult to imagine how the arms

could be modified or suppressed after they are once formed; nevertheless in practically all examples of division seen, I have found the arms well developed before the escape of the daughter cells (FIGS. 20, 21) so that such cells can hardly be looked upon as a reversion to the simpler ancestral form.

The main difference between this new form and Bohlin's type lies in the fact that the arms are here always rounded and obtuse, while in the type form they are sharp pointed and often more slender. The characters of the form may be summarized as follows:

BRACHIOMONAS SUBMARINA Bohlin, forma **obtusa** f. nov. *B.* cellulis vegetativis figura structuraque formae typicae similibus, sed brachiis cornuque posteriore obtusis; cytoplasmate et chromatophoro alias in extrema ipsa extendentibus, alias ex eis plus minusve retractis.

Longit. cellularum 15–32μ (saepius 20–25μ); lat. cell, 15–22μ (saepius ca. 18μ).

Hab. in aquis subsalsis lacunarum saxearum. Twin Island, Pelham Bay, New York; Nov., 1919, Feb.–March, 1922.

Chodat's figures (2, *f. 66*) indicate that the form collected in Corsica may be identical with the one here described, though it is possible that the difference between his sketches and those of Bohlin may be due to the personal equation in drawing.

As indicated above, I have found this obtuse form only at one station. Bohlin's type, as represented by my FIG. 1–3, I have also collected early in September during each of the past two years at Bass Point, Nahant, Massachusetts. It should be looked for on the coast of Maine and New Brunswick as well, at any points where rocky ledges occur.

In older cultures numerous cells were found which showed the entire protoplast contracted into a globose mass (FIG. 16). These showed no further development in this material; but in fresh hanging drop cultures of *B. submarina* followed for a much shorter time in Norway, such cells presently became quiescent and developed a new spherical wall closely investing the protoplast. Soon these aplanospores showed their chromatophore turning from green to a tawny tint, and finally the original wall of the zoospores gradually disappeared.

Practically all genera allied to *Chlamydomonas* possess two contractile vacuoles pulsating more or less in alternation, situated near the base of the cilia. In *Brachiomonas* these appear to be entirely absent. One of West's figures (12, *pl. 20, f. 11*; 14, *f. 101 c*), it is true, suggested such vacuoles, but his

beautiful original sketches in color, preserved with his collection of drawings in the South Kensington Museum, show that these spots are brown colored granules suspended in the fluid of a large permanent vacuole. The absence of contractile vacuoles I have been inclined to regard as another mark of the highly specialized character of the genus, since they are regularly to be expected in primitive members of this group and its ancestors. It is possible, however, that this peculiarity is merely an incident due to the special habitat; for Bütschli has remarked the general absence of contractile vacuoles in marine Ciliates and Rhizopods, and D'Arcy Thompson (**11**, pp. 165 and 264) regards this absence in such cases as "no more than a physical consequence of the different conditions of existence in fresh water and in salt." The marine species, *Chlamydomonas brachyura* West, besides exhibiting other points of resemblance to *Brachiomonas*, appears also to have no contractile vacuoles; this species was discovered in association with a new Carteriaceous genus *Platymonas*, in which West (**13**) found two small contractile vacuoles, which, however, "could only be observed with difficulty." In two brackish water species of *Platymonas* which I have investigated with considerable care, I am unable to satisfy myself that I ever see contractile vacuoles. Lewis has just published figures of one of these species, *P. subcordiformis* (Wille) Hazen,* which likewise show no contractile vacuoles. Furthermore, two new brackish water forms of the primitive family Polyblepharidaceae, one a minute species of *Pyramimonas* and the other a new genus most closely related to *Polyblepharides*, which have turned up in my latest collections of *Brachiomonas*, made while this paper was in the hands of the printer, very certainly possess no contractile vacuoles. Over against these several records of their absence, however, attention may be called to their presence (though here very small) in *Chlamydomonas caudata* Wille, discussed below, which must be considered as regularly a marine organism.

Asexual reproduction is accomplished by internal division into four or eight (very rarely perhaps two) daughter cells. The division very generally begins while the cell is swimming actively, and often the typical cell shape is acquired by the daughter cells or zoospores and they move with their own cilia inside the mother cell-wall while it continues in active movement

* Notes from the Woods Hole Laboratory,—1921. *Platymonas subcordiformis* (Wille) Hazen. Rhodora **23**: 249–251. *pl. 133, f. 1–19.* Mr 1922.

by its own cilia. Bohlin states that the first division is longitudinal, and certainly this is regularly the case. Chodat presents a figure (2, *f. 66*), and I have seen two or three such cases, where the first division appears to be transverse, but it is quite possible that such an appearance is due to an unusual shifting of the position of the cell contents after a proper longitudinal division. The subsequent divisions have not been described or figured by previous observers, and are ordinarily difficult to follow because of the continual active movement of the mother cell. I was so fortunate as to find one very favorable case in *B. submarina* f. *obtusa*, and later many similar ones in the type form, which I believe to be entirely representative. This individual became quiescent after the first division was completed (FIGS. 22, 23); it presented its anterior pole upward, so that it was possible to see easily that the second plane of cleavage is also longitudinal and perpendicular to the first. Immediately after the second cleavage a slight stretching and shifting of the daughter portions took place, so that one of them appeared somewhat underneath two others (FIG. 24). The third cleavage appears to cut each of the four daughter portions across its longer diameter, that is the plane seems to be essentially transverse to the previous divisions and to the axis of the mother cell. The pyrenoid disappears before the first cleavage occurs, and the stigma fades out during this process. A new and rather small pyrenoid appears in each daughter portion after the second cleavage, and probably another pyrenoid arises *de novo* in four of the eight daughter cells. About an hour after the completion of the third cleavage the eight daughter cells had acquired the typical form of the arms, and also the eye-spot and cilia (FIG. 27); after about another hour they escaped from the mother cell-wall. In certain cases it is clear that the cilia of the mother cell remain connected by a strand of protoplasm to one of the daughter portions during division (FIG. 19) or even until the eight zoospores acquire their final form. Whether this is regularly the case appears doubtful. In material identified as *Brachiomonas gracilis* Bohlin, at Aalesund, Norway, I observed numerous cases of division which followed the course outlined above.

In the case of the production of only four daughter cells it is clear that the cytoplasmic polarity of the mother cell would be directly transferred to each of the new zoospores. But when division proceeds further it is less clear how the

polarity may be transmitted: for, as stated above, the third plane appears to cut the four daughter portions transversely in such a manner that half of the resulting eight would retain the original anterior cytoplasm, while the four posterior zoospores would seem to be under the necessity of regenerating (so to speak) their anterior pole. It is possible that in the slight shifting of the daughter portions following so quickly upon the first two divisions there is actually more rotation than is apparent so that the third division may effect a properly qualitative bipartition, but that appears doubtful from the cases observed. The whole problem of polarity in chlamydomonads is one of great interest demanding a degree of care in observation which hardly any species up to the present has received.

Brachiomonas simplex sp. nov.

This species was first discovered at Aalesund, Norway, in the last days of June 1920, and was also collected three weeks later at Cullercoats, near Newcastle-upon-Tyne, and in August at Plymouth, England. It was found in small rock pools of brackish water, sometimes in association with one of the other species of *Brachiomonas*, then again in practically a natural pure culture.

At first sight the organism looked like a *Chlamydomonas*, many individuals (FIGS. 31, 39) showing somewhat the general oval, posteriorly pointed form characteristic of *C. caudata* Wille (FIGS. 46–50), which occurred near by, though never in the same pools. But presently it was noticed that even the cells most nearly approaching *C. caudata* in form were nevertheless more like *Brachiomonas submarina* in internal organization, showing a similar linear stigma and large lateral and anterior pyrenoid; furthermore many individuals show small bumps or protuberances slightly back of the middle region, immediately suggesting the arms of *Brachiomonas*, though never really attaining that character (FIGS. 28, 29). The posterior horn, often rather elongated, shows a characteristic curve not seen in *B. submarina*. Generally the protoplast was conspicuously furnished with vacuoles, but whether this is a constant character is somewhat doubtful, inasmuch as *C. caudata* in similar pools was often similarly vacuolate at this time. The English material, moreover, was much less vacuolate. There is great variability in the development of the lateral protuberances; if formed at all they appear before the escape of the zoospores

from the mother cell, and the form then attained persists through the life of the individual. In newly formed zoospores, usually, but not always, the protoplast and chromatophore extend into the posterior horn so as to fill it completely. In older individuals the protoplast gradually retracts so that a considerable portion of the horn, or finally all of it is empty. The pyrenoid and red eye-spot regularly lie on the same side of the cell, and the nucleus on the opposite side; as in *B. submarina*, this is most clearly shown in cells momentarily resting with one of the poles directed upward (FIG. 32).

As in the other species, asexual reproduction is accomplished by division of the protoplast into four or eight daughter cells which develop the characteristic form while the mother cell still retains its cilia in active movement (FIGS. 35, 36).

In sexual reproduction, gametes may be formed to the number of thirty-two in one mother cell, which retains its motile condition until they are completely developed (FIG. 40) just as in the case of asexual reproduction. The gametes are similar in form to the asexual cells, but much smaller, lacking a cell wall, and furnished with relatively longer cilia: they also seemed to be more apt to show angularity in the middle region than the asexual cells. Usually there was a slight differentiation between the pair, a smaller and more fusiform gamete conjugating with one slightly larger and more angular (FIGS. 41, 42). Meeting by the ciliated anterior ends, the fusion is lateral, resulting in a quadriciliate zygote of ovoid-pyriform shape which swims actively, and may for some time show the two nuclei, two pyrenoids, and two linear eye-spots (FIG. 43); when momentarily at rest the four long cilia trail backwards. Finally the nuclei fuse, the cilia disappear (FIG. 44) the form becomes spherical, and the thick wall of the resting zygospore is developed (FIG. 45). After some days the cell contents assume a reddish orange color similar to that of the aplanospore of this species and of *B. submarina*.

Brachiomonas simplex sp. nov. *B.* cellulis vegetativis majoribus, plerumque oviformibus quidem sed ad posteriorem partem in cornu curvatum productis, brachiis quae ceterae hujus generis species habent aut omnino suppressis aut evolutis tantummodo in 2–4 gibbos exiguuos subangulares vel rotundatos; ad polum autem anteriorem globosis vel papilla conica parvula exornatis: chromatophoro cellulam prope complente aut non longe in cornu posterius se extendente, pyrenoidem lateralem modo in medio modo a fronte habente, saepe vacuola majuscula

plura praebente: puncto rubro (stigmate) lineari prope pyrenoidem sito: nucleo ad latus oppositum cellulae intra partem chromatophori excavatam complexo: ciliis binis ca. ¼ brevioribus quam cellula instructis.

Propagatio fit per cellulae vegetativae impigre natantis divisionem in 4 vel 8 zoosporas, quae tegumenti scissura erumpunt. Praeterea aplanosporae, primo virides, postea paulatim ad colorem fulvum transmutatae, per contractionem protoplasti in massam globosam ad cellulae partem anteriorem, ut in *B. submarina*, efficiuntur.

Generatio fit per copulationem gametarum inter se subaequalium et nudarum, quae cellulis vegetativis forma quidem similes sunt, sed perparvae et ciliis quam corpus ipsum multo longioribus praeditae, quaeque per divisionem cellulae vegetativae protoplasti etiam in 32 individua parturiuntur. Zygosporae globose, tegumento levi vestitae, diametro ca. 12μ.

Longit. cellularum veg. 30–48μ, lat. 18–24μ. Longit. gametarum 13–15μ, lat. 6–8μ; longit. ciliorum ca. 18μ.

Hab. in aquis lacunarum saxearum subsalsis. Aalesund, Norway, 28 June, 1920; Cullercoats, Northumberland, England, 19 July, 1920; Plymouth, England, 11 August, 1920.

Because of the fact that unarmed individuals appear in older cultures of *B. submarina*, one might be tempted to inquire whether *B. simplex* is merely a form of that species. Nevertheless in the natural pure cultures seen both at Aalesund and at Plymouth, *B. simplex* maintained its characteristic simplicity of form from the earliest development of the daughter cells to maturity, and even when it was found intermingled with one of the other species it showed a distinctive character, particularly in the curving of the posterior horn, which rendered it always recognizable. Again, the variability of form exhibited by this new species might readily suggest for it a hybrid origin. We know little of hybridization among algae, but a very interesting preliminary report of its occurrence in *Chlamydomonas* has recently been published by Pascher (**7**). It may be remarked that Pascher's heterozygous cells showed great diversity in internal organization, while here in *B. simplex* only variability of external form is found. From a careful consideration of all the conditions of its habitat and its behavior, I am convinced that *B. simplex* is to be regarded as a distinct species which represents the transition from *Chlamydomonas* to the more characteristic species of *Brachiomonas*.

There is some resemblance between this species and *Chlamydomonas brachyura* West (**13**) a form which developed in a tank of seawater sent from Plymouth to Birmingham in 1915, and for

which I searched vainly at Plymouth in 1920. Nevertheless since *C. brachyura* lacks a red eye-spot and is pointed instead of rounded at the anterior end, we may perhaps find more suggestion of the origin of *Brachiomonas* in the species mentioned at the beginning of this section, namely,

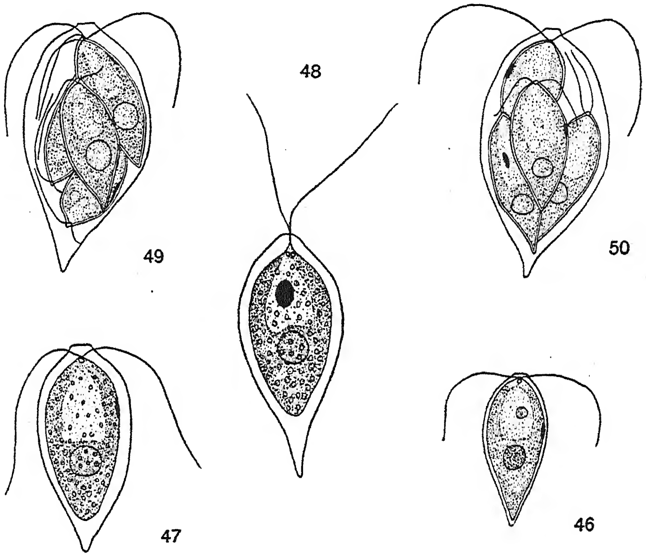
CHLAMYDOMONAS CAUDATA Wille

This very interesting and apparently rare species was found June 28, 1920, at Aalesund, Norway, in small rock pools of the same character as indicated in the original account in 1903 (**15**, pp. 115–118, 135, *pl. 3, f. 4–11*) and my determination of the species was later confirmed by Professor Wille, from living material which I carried to him in Christiania. In one pool was a practically pure culture, giving an intense green color to the brackish water; in another pool close by was a considerable admixture of *C. subcaudata* Wille, which was certainly the most abundant species of the region, now as in 1902. Why *C. caudata* should occur in only three or four out of many similar pools is an interesting question. It was also surprising that it could not be found on the English coast, where the conditions appeared to be much the same, and where I did find several of the other brackish-water species which were associated with *C. caudata* at Aalesund. This species appears not to have been found elsewhere than at this original station.*

The elongated oval posteriorly pointed form of the zoospores is very notable in comparison with the rounded form of the commonly known species of *Chlamydomonas*. The strong resemblance to the more reduced forms of *Brachiomonas simplex* is equally striking; so much so, in fact, as intimated above, that upon superficial observation the two species might be mistaken for closely related members of the same genus. Ordinarily in active individuals, especially in newly formed zoospores, the protoplast conforms rather closely to the shape of the cell-wall, being merely rounded at the point of insertion of

* Playfair, to be sure, has reported [Proc. Linn. Soc. New South Wales **43**: 515. 1918] a form found apparently in fresh water of which he writes: "The only tailed species of *Chlamydomonas*; it is impossible to make any mistake in the identification." Since, however, Playfair states that his specimens lacked pyrenoid and stigma, and his figure shows a distinctly different morphology of the anterior portion of the cell, including a different position of the nucleus, there can be no justification for trying to identify his form with a species so well defined as *C. caudata*, at least until cultural evidence is brought forward to support the attempt.

the cilia, and tapering to an acute point at the posterior end FIG. 46). Older individuals, kept for two weeks or longer in hanging drops, show the cell-wall much thickened, or the protoplast contracted and rounded posteriorly and produced into more or less of a beak at the anterior end (FIGS. 47, 48). The broad truncate anterior papilla of the cell-wall (Hautwarze) impresses me as being rather more prominent than shown in



FIGS. 46–50. CHLAMYDOMONAS CAUDATA Wille

46. Young cell, "dorsal view," showing typica lposition of nucleus, stigma, and pyrenoid. 47. Older cell with thickened wall. 48. Similar cell in "lateral view." 49. Typical arrangement of daughter cells. 50. Unusual arrangement of daughter cells. All, × 720, approximately.

Wille's (15) figures, and the red eye-spot, first described as 'langgestreckter' and again as 'oval oder stabförmig,' was in my mature specimens always a strongly oval disc, sometimes with an anterior pointed end, showing its thinness in the fact that the edge view was narrowly linear. These differences may be readily accounted for by differences of magnification during observation. The longitudinal streaking of the chromatophore noted in the original description, and even introduced in Wille's key to the species, was never distinguishable in vigorous material of either this species or *C. subcaudata* in 1920; only certain individuals kept for ten days or more in

hanging drop cultures showed almost a lattice-like appearance of the chromatophore. Although the chromatophore is hollowed out about as far as the middle of the cell, or sometimes even more deeply, nevertheless the position of the nucleus is notably less central than might be expected, for it lies approximately in the anterior third of the cell.

A point of considerable interest is the position of the stigma and contractile vacuoles. Regularly the eye-spot is so placed that when the cilia are stretched out in a plane parallel to the stage of the microscope the stigma lies on the apparent right side of the cell and in a slightly upper focus, or with the cell revolved 180° the stigma lies on the apparent left side and at a slightly lower focus; in such a position only one of the small contractile vacuoles is visible. If the cell is revolved only 90° from the first position, so that one of the cilia lies nearer the observer and the other at a somewhat lower focus, the stigma shows its disc-like shape in an upper central focus (FIG. 48) and the two contractile vacuoles may be seen side by side at the same time, though one is always smaller than the other, on account of the alternation in their pulsations. This position of the stigma and cilia in one plane and the contractile vacuoles in another plane perpendicular to it indicates a dorsi-ventral character of the cell which appears to me to be the rule in many species of *Chlamydomonas*, though it seems to have received little or no attention from students of the group.*

The dorsiventral differentiation in *Brachiomonas*, as mentioned above and indicated in FIGS. 6, 7, 13, 15, and 32, is slightly different; there the cilia normally stretch out in a plane perpendicular to that which passes through the stigma, pyrenoid, and nucleus, and most commonly the zoospore comes to rest with the stigma lying exactly in the middle on the ventral side, or (less often) on the dorsal side, toward the observer. In many of the figures which seem to indicate a different relative position of the eye-spot and cilia, the latter were actually lying in a plane oblique to that of the microscope stage, which could not easily be shown in the drawings.

* There are, it is true, many published figures of *Chlamydomonas* which show the two contractile vacuoles side by side apparently in the same plane with the cilia; but in cells exhibiting so much movement it is very easy to transfer what is seen in one view to a sketch representing in general a different view, unless one is keenly on the lookout for such a point. Probably also many of our somewhat classic figures are not made from camera lucida drawings of quiescent individuals, as they should be to determine such features.

In the asexual reproduction of *C. caudata*, Wille describes the division as longitudinal, after the disappearance of the cilia of the mother cell, resulting in the formation of four zoospores. On several occasions when I examined material with my travel microscope in the field in late afternoon, or freshly collected material in early evening, I found numerous individuals which contained the four fully formed zoospores while the mother cell was still swimming actively. It was only in the more rarely seen divisions of material kept for a day or two after collection that I found non-motille cells in process of reproduction; such cells may have lost the power of movement earlier because of poorer aeration than in the normal habitat. This division of actively motile cells I have found to be normal in several other species of *Chlamydomonas*. I was unable to find examples which would actually show more of the details of the process of division than indicated by Wille, who merely furnishes one figure of completed division. I did, however, observe that a large majority of cases showed two of the daughter cells with their anterior end directed forwards, and two with the anterior end directed backwards (FIG. 49). In other species of *Chlamydomonas* such as arrangement of the daughter cells is characterstically found when the first plane of division appears transverse to the longitudinal axis of the mother cell, or when, though fundamentally longitudinal, the plane becomes placed transversely by a rotation of the entire protoplast. During the past season I have had the opportunity of observing this latter method many times in a new species to be described in a future paper: this species furnished one exceptional case in which both divisions, carefully followed, were strictly longitudinal, resulting in four zoospores all headed toward the anterior end of the mother cell. This exceptional arrangement I also found in rare instances in *C. caudata* (FIG. 50). Wille's figures (**15**, *pl. 3, f. 8*) which shows the same arrangement, appears, therefore to be untypical, and I am obliged to believe that the first division of this species, though properly longitudinal, would regularly show as a transverse cleavage, in consequence of a rotation of the protoplast to such an extent that its anterior pole comes to lie in a position nearly in the middle of the length of the cell.

Reichenow (**9**, **10**, pp. 35–39) it is true, has expressed the view that the division in all species of *Chlamydomonas* may be fundamentally longitudinal, an apparent transverse division being al-

ways preceeded, in his opinion, by a rotation of the protoplast, so that he believes the manner of cell division to have no phylogenetic significance. Attractive as this view is in its possibility of simplifying the idea of direct transmission of polarity to the daughter cells (and my own recent studies on *Chlamydomonas* somewhat tend to support such a view) nevertheless we still lack sufficiently definite and accurate observations to permit the denial that an actual transverse division may occur in some species.

If in *C. caudata* the first cleavage plane is actually or by rotation of the protoplast transverse (as appears to me most probable), and if we accept the current view derived from Dill (4) that the most primitive species are those in which both divisions are longitudinal, then *C. caudata* could hardly be regarded as an actual transitional form between the ordinary ovoid *Chlamydomonas* type and the *Brachiomonas* group, since all species of the latter genus appear to have retained the primitive mode of division by two strictly longitudinal cleavages, in spite of their advancement in other respects. Nevertheless, in its general morphology, and in the similarity of its method of formation of aplanospores (rarely found in other species of *Chlamydomonas*), *C. caudata* must be very close to the ancestral line which has given rise to the four forms of *Brachiomonas* recognized above; and these present a rather close ascending series, with perhaps a definite orthogenetic tendency beginning with *B. simplex*, which is barely emerging from the *Chlamydomonas* stage, through *B. submarina f. obtusa* and then *B. submarina* (type) to *B. gracilis*, an extremely slender form, so far removed from any *Chlamydomonas* type as to justify thoroughly the retention of *Brachiomonas* as a genus.

In certain graphic schemes of the phylogeny of the chlamydomonads—e. g. those of Wille (**15**) and West (**14**, p. 163)—the genus *Lobomonas* Dangeard is indicated as representing an intermediate stage between *Chlamydomonas* and *Brachiomonas*; but the two known species of *Lobomonas*, as well as two new species to be described by the writer in the next number of this journal, are very minute forms, and in their general morphology exhibit by no means so good a connection as is shown by *C. caudata* and *B. simplex*. *Lobomonas* must be regarded as a special offshoot from the *Chlamydomonas* line not leading to anything higher, so far as we know at present.

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Description of plates 3 and 4

All drawings made with the aid of camera lucida from living material in hanging drop cultures (or in some cases freshly fixed with osmic acid vapor): PLATE 3 done with Leitz 1/12 in. oil immers. obj. and compens. oc. 6, magnifica-

tion about 1440 diameters; plate 4 done with Spencer 2 mm. oil immers. obj. and Leitz compens. oc. 6, magnification about 1300 diameters; both reduced in reproduction to about 720 diameters.

PLATE 3

FIGS. 1–7. BRACHIOMONAS SUBMARINA Bohlin, type form

FIG. 1. Vegetative cell; posterior horn filled with colorless cytoplasm.

FIG. 2. Chromatophore filling the extremities: Dec. 1919.

FIG. 3. Colorless cytoplasm in extremities; stigma and pyrenoid lying on the under side of the cell: March, 1921.

FIG. 4. Anterior polar view of similar cell; vacuoles in chromatophore.

FIG. 5. Slender form similar to Bohlin's *f. 1b* of *B. gracilis* (fixed with osmic acid vapor).

FIG. 6. Moderately slender form: showing typical position taken by living zoospore temporarily at rest, the pyrenoid and stigma lying in the center of the under side (osmic vapor): April 1921.

FIG. 7. Anterior polar view of similar cell, showing cilia stretching out in plane perpendicular to that in which the nucleus, pyrenoid, and stigma typically lie.

FIGS. 8–27. BRACHIOMONAS SUBMARINA forma OBTUSA Hazen

FIG. 8. Chromatophore contracted, arms and horn filled with colorless cytoplasm (osmic vapor): November, 1919.

FIGS. 9, 10. Arms empty, colorless cytoplasm extending into posterior horn (osmic vapor).

FIG. 11. Anterior polar view of similar cell, living.

FIG. 12. Arms and horn nearly empty (osmic vapor).

FIG. 13. Posterior polar view of similar cell, living, showing typical relative positions of organs as in FIG. 7; a large colorless cytoplasmic region around the nucleus.

FIG. 14. Older cell showing no trace of arms.

FIG. 15. Cell from old culture with only a suggestion of lateral arms; stigma and pyrenoid lying underneath the nucleus.

FIG. 16. Senescent cell with contracted protoplast, preparing to form an aplanospore: December, 1919.

FIG. 17. Young cell showing nucleus posterior to pyrenoid.

FIG. 18. Posterior polar view of similar cell.

FIG. 19. First division of motile cell; 10:30 P. M. (osmic vapor).

FIG. 20. Eight zoospores fully formed in motile mother cell.

FIG. 21. Four zoospores: cilia of mother cell no longer present.

FIGS. 22–27. Successive stages in division resulting in eight zoospores (November, 1919): FIG. 22 at 2:40 P. M.; FIG. 23 at 3:40; FIG. 24 at 4:50; FIG. 25 at 5:30; FIG. 26 at 6:20; FIG. 27 at 7:40. The zoospores escaped before 8:40.

PLATE 4

BRACHIOMONAS SIMPLEX Hazen

Drawn 29 June—4 July, 1920, Aalesund, Norway.

FIGS. 28, 29. Typical mature vegetative cells: in FIG. 29 the stigma lies slightly underneath.

FIG. 30. Anterior polar view of similar cell.

FIG. 31. Cell on which the "bumps" representing lateral arms are undeveloped.

FIG. 32. Anterior polar view of similar cell.

FIG. 33. Protoplast ertracted from one of the "bumps" (osmic vapor).

FIG. 34. Large older cell with more posterior pyrenoid.

FIG. 35 Eight zoospores in motile cell; 12:45 A. M.

FIG. 36. Four zoospores in motile cell.

FIG. 37. Young zoospore free; chromatophore filling posterior horn.

FIG. 38. Three of the four zoospores have escaped through a triangular rent in the wall of the mother cell.

FIG. 39 Similar to FIG. 31, but with more typical position of pyrenoid (osmic vapor)

FIG. 40. Thirty-two gametes in motile mother cell; 10 A M.

FIGS. 41, 42. Gametes at beginning of conjugation (osmic vapor).

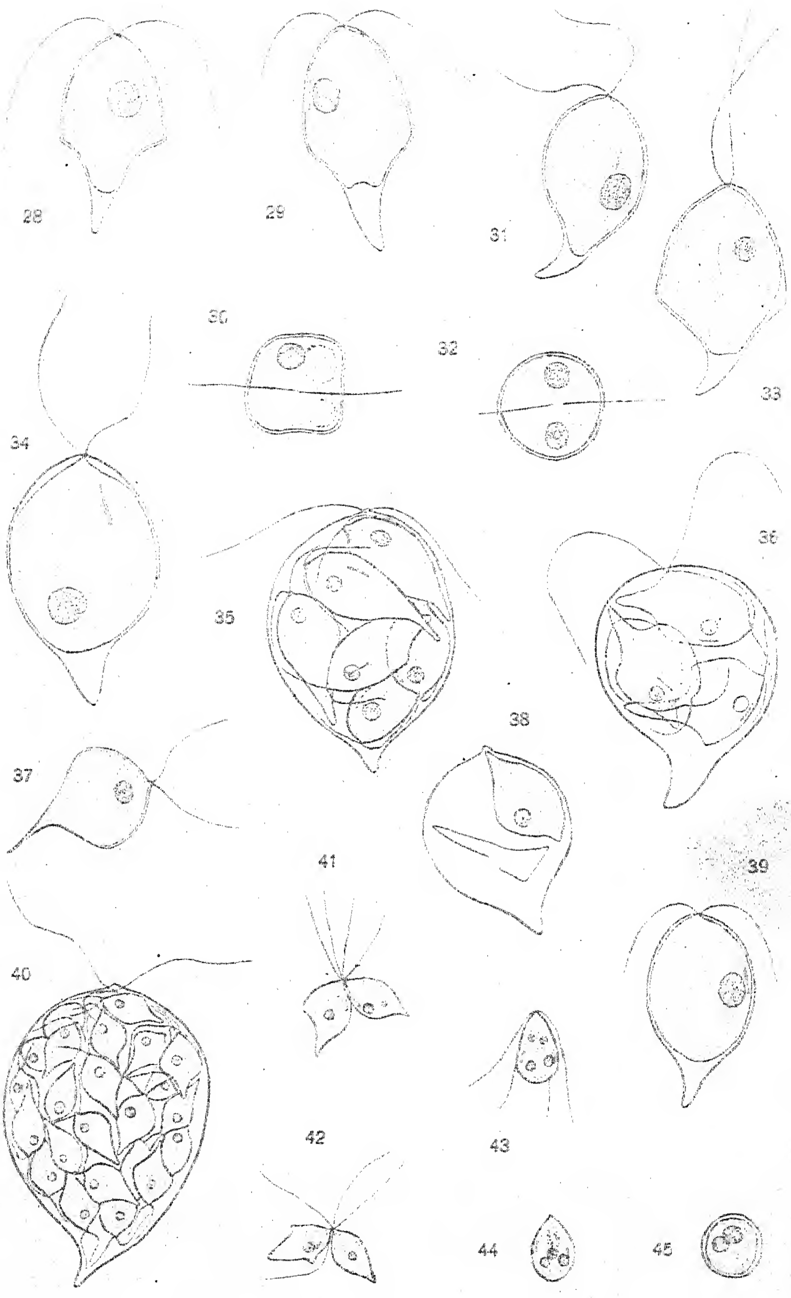
FIG. 43. Motile zygote, momentarily resting; nuclei not fused.

FIG. 44. Zygote, cilia having disappeared, nuclei fused; two stigmata still present.

FIG. 45. Zygospore twenty-four hours after conjugation.

In the living cells the pyrenoid actually appears upon casual observation to be green because imbedded in the green chromatophore. It is believed, however, that the printing of the pyrenoids in the same sepia as the cell-wall and protoplasmic outlines represents more truthfully their real nature.

Note. As final proof of this paper is received, the writer has just made a mid-April excursion to the Massachusetts coast, where he has collected typical *Brachiomonas submarina* Bohlin from Cape Ann to Buzzards Bay, at Rockport, Gloucester, Marblehead, Nahant, and Fair Haven. There has been no indication of other species of *Brachiomonas* or of *Chlamydomonas caudata* at these stations.



BRACHIOMONAS SIMPLEX HAZEN

New records and other notes on North Dakota plants*

O. A. STEVENS

The present paper is supplementary to Bergman's Flora of North Dakota (in Sixth Bien. Rept. Agr. Coll. Survey [1911–1912]. 1918) and, as such, will follow the same arrangement and nomenclature. The purpose is to record additional species, designated by a dagger (†), and other notes of special interest. During the years 1910 to 1920 I have had opportunity to visit nearly every part of the state and, incidental to economic work, to obtain many specimens of interest. Some of these were noted in the Flora and others have been reported by Lunell (Am. Mid. Nat. 4–6. 1917–1919). I have also included in the paper a few corrections which have come to notice and revised certain groups in which I have become especially interested. Where not otherwise stated, the specimens listed have been collected by myself.

LEPIDIUM RAMOSISSIMUM A. Nels. I do not know why Bergman reduced this to a synonym of *L. densiflorum* Schrad. The two species are very different and may be distinguished as follows:

L. densiflorum. Annual, stem usually simple below and with several long racemes above; basal and lower stem leaves serrate; pods distinctly margined and broadest toward the apex.

L. ramosissimum. Biennial, bushy branched from the base; basal and lower stem leaves pinnatifid, the lobes linear or oblanceolate; pods not margined above, elliptic in outline.

The following specimens belong to *L. ramosissimum*: Tower City, *Bergman 870*; Valley City, Aug. 13, 1912, (first year rosettes); Courtenay, June 20, 1911; Kensal, July 26, 1915, (rosettes, also flowering stems); Manfred, July 12, 1913; Sykeston, July 15, 1891, *Bolley*; Sheyenne, July 4, 1908, *Lunell;* Leeds, Aug, 1, 1912; Bathgate, July 22, 1892, *Lee;* Ganbetta; *Bell 264*; Rugby, *Bergman 2611*. This species is quite common throughout the central part of the state, growing about streets and dooryards rather than in fields. At Langdon on July 19, 1918, I noticed the rosettes of *L. ramoisssimum* fairly covering

* Contribution from Department of Botany, North Dakota Agricultural College and Experiment Station.

the ground. In a dooryard at Courtenay the species grew mixed with *L. densiflorum*. The latter had racemes about 3 cm. long with numerous well-developed pods, while the plants of *L. ramosissimum* had only a few half-developed pods.

† LEPIDIUM DRABA L. Several years ago (Ann. Rept. North Dakota Exp. Sta. **22**: 80. 1912) I called attention to the possibility of this being introduced in Turkestan alfalfa seed. On June 6, 1918, a flowering plant was sent me by Mr. H. A. Nelson of Ray. [A well established colony has since been found along the railroad track at Moorhead, Minnesota, May 22, 1921.]

† SISYMBRIUM LOESELII L. Determination verified by Paul C. Standley and specimens deposited in herbaria of the U. S. National Museum and the New York Botanical Garden.

Annual, 6–9 dm. high, sparingly hirsute with simple flattened hairs, these less abundant above but present on upper stems and pedicels; leaves runcinate, the terminal segment hastate and irregularly denticulate, lower stem leaves sometimes 1 dm. long; racemes becoming 3–4 dm. long, pedicels widely spreading one third to one half the length of the slender pods, which are ascending and about 3 cm. long with three-nerved valves.

Devil's Lake, July 15, 1920 (common about the streets); Tappen, July 12, 1919 (a single plant in the street; several in an old field of *Bromus inermis* Leyss. several years before). The description was drawn from the growing plants and specimens collected at Devil's Lake. The plant has somewhat the aspect of *Sophia intermedia* Rydb., but the leaves are quite different and the racemes are fewer but longer and coarser. The relative height of flowers and young pods mentioned by Koch and others seems scarcely distinctive. In this plant the pods do not surpass the flowers in normally developed racemes, but examples are frequent where they do so, apparently as a result of arrested development.

ERUCASTRUM POLLICHII Schimp. & Spenn. Park River, Aug. 8, 1913; Williston, Aug. 15, 1915; Oakes, July 18, 1919; Cooperstown, Aug. 25. 1919. This has now been found at many places, chiefly along the railroad tracks. The seeds have been identified in several samples of timothy and millet coming from near Grand Forks or a short distance north or south of this locality. The pods are not flattened, as stated in Bergman's key, but rounded, the valves with a rather prominent mid-nerve; racemes leafy bracted. The plants grow vigorously in late fall as shown by a flowering specimen collected at Fargo, Oct. 26, 1914.

MALVA VERTICILLATA L. I have not seen the specimen which Bergman referred to this species but am inclined to think that it was *M. borealis* Wallm., which is the common plant at Fargo and other places in the state. A specimen of what seems to be *M. crispa* L. † was sent by A. G. Sorlie, Grand Forks, Oct. 10, 1916.

EUPHORBIA ESULA L. Wahpeton, June 3, 1920, *Geo. P. Wolf;* Hazelton, July 15, 1919, in field of *Bromus inermis*; New Rockford, July, 1911, *J. R. Campbell*; Mona, June 5, 1914, *Albert Graves*; Ray, July 2, 1917, *H. A. Nelson.* In one field near Fargo patches are scattered over 20 acres. Apparently a bad weed, spreading by the roots. Time and manner of introduction unknown.

† SILENE DICHOTOMA Ehrh. Edgeley, July, 25, 1917, *Brenckle;* Langdon, July 19, 1918; Regent, July 20, 1916, *A. C. Goldtrap.* In timothy fields. Plants grown from seed proved to be coarse biennials larger than *S. noctiflora.*

† SILENE FABARIA (L.) Sibth. & Sm. Specimens determined by Paul C. Standley.

Biennial; glaucous, much branched, 6–9 dm. high. Basal and lowest stem leaves narrowed at the base, larger stem leaves ovate, sessile; flowering stems dichotomous with a flower in the fork, each branch with several remote clusters of three to seven flowers each. Flowers about 1 cm. wide, white, opening at night; petals cleft to the throat, not appendaged, the lobes oblanceolate, rounded at the apex; calyx indistinctly fifteen-ribbed, closely investing the ovate horny capsule, but not especially enlarged in fruit.

Venturia, July 16, 1919; Oakes, July 18, 1919. Lower stems and leaves with very much the aspect of *Vaccaria Vaccaria.* A specimen in the herbarium of Dr. J. F. Brenckle was collected at Kulm by him in 1916, and he states that he had found the plant there previous to that date. Apparently well established at Oakes and Venturia along roadsides. Dr. Standley writes that this is probably the first time it has been collected in this country.

† LYCHNIS ALBA Mill. Devil's Lake, July 13, 1920.

CHENOPODIUM

For several years I have been interested in *C. album* and related forms, especially in regard to seed characters. The plants are rather difficult to collect as the seeds are slow in maturing and the lower leaves are likely to be lost by the time the fruiting branches are well matured. With respect to the adherence of the pericarp it is to be noted that it rubs off more easily in fresh material.

In the fall of 1916 I collected twenty-six specimens in the vicinity of Fargo and submitted them to Dr. Standley, who determined them as follows:

C. album (4);
† *C. paganum* Reichenb. (11);
C. paganum, approaching *C. album* (8);
† *C. ferulatum* Lunell (3).

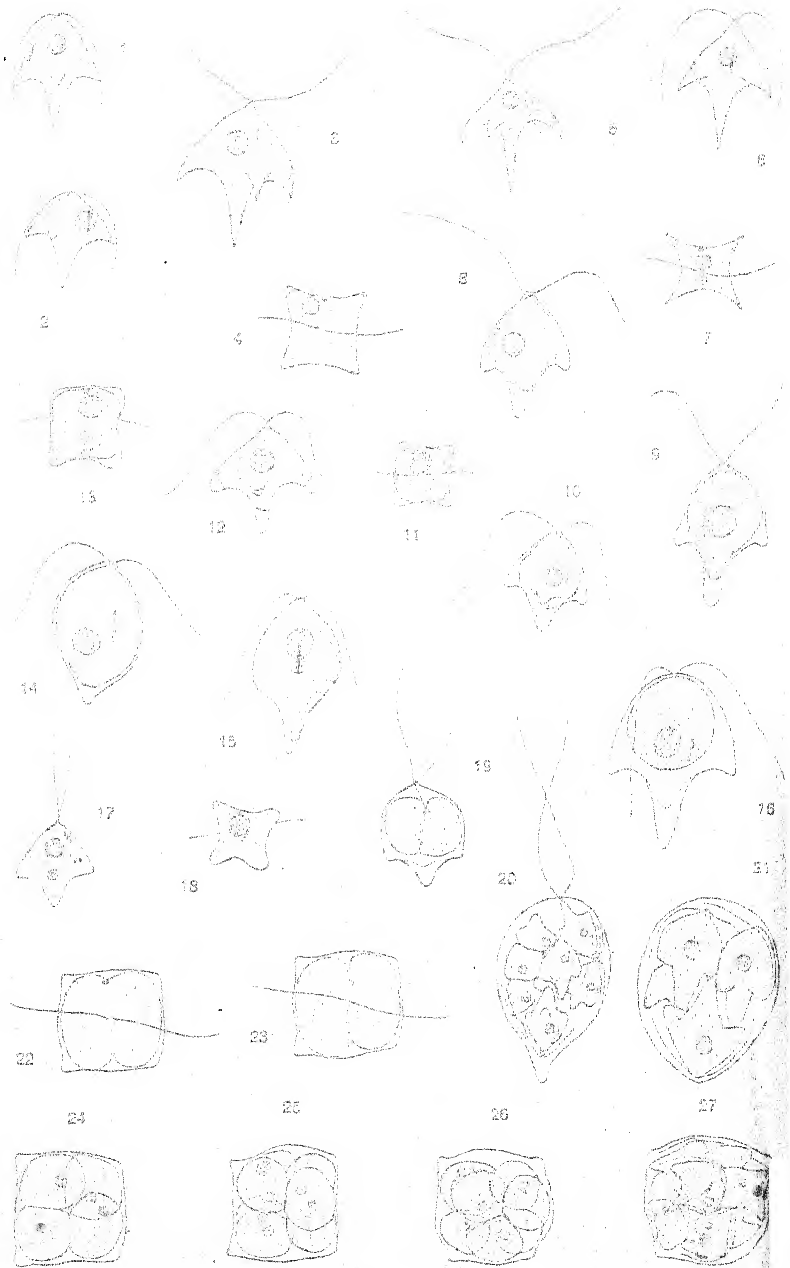
Apparently *C. paganum* is the commonest form here. I have not as yet been able to make much further progress in clearing up the relations of these forms but wish to offer what few notes I have.

C. ferulatum (which Standley notes is perhaps not sufficiently distinct from *C. album*) is separated by the fruiting calyx being open, exposing the fruit. While this does not seem to be quite constantly true for *C. ferulatum*, I find it also in a rather variable degree in the *C. album* specimens, being most prominent in well-matured plants. No. 11, determined as *C. paganum*, has calyces closed in specimen collected Aug. 25, but fruit from same plant collected in September shows them quite open. As to *C. paganum*, most of the plants were either so badly infested by an insect or so late in maturing that very little mature seed was obtained. From material at hand I would describe the seeds as follows:

C. album—1.2–1.4 mm. wide, upper surface flattened and with shallow, oblong pits (which show through the pericarp).
C. paganum—1.2–1.4 mm. wide, upper surface dull, neither flattened nor pitted.
C. ferulatum—1.2–1.4 mm. wide, similar to *C. paganum*.
C. leptophlyllum—0.9 mm. wide, not flattened, smooth and shining.

The size of the seed of *C. paganum* is given by Standley (N. Am. Fl. **21**: 21. 1916) as 1.3–2 mm. In one of the twenty-six specimens, a plant collected near the woods along the Red River, the seeds are variable in size, measuring 1.4–2 mm., but in all the others they are scarcely larger than those of *C. album*.

The three specimens of *C. ferulatum* differ among themselves. One, collected in an old garden (No. 3), which I take to be typical, is pale grayish green, simple below and with short branches above, the leaves oblong-rhombic with four or five short teeth on each side; another (No. 9, labelled by Standley as apparently a form of *C. ferulatum*) is bushy branched with narrow entire leaves. The third (No. 2) is in a rather advanced condition with lower leaves mostly fallen; the flowering branches



1-7. BRACHIOMONAS SUBMARINA Bohlin
8-27. BRACHIOMONAS SUBMARINA forma OBTUSA Hazen

are unusually thick and dense and the seeds are pitted on the upper side. I am inclined to think it is a plant of *C. album* with an unusual amount of well-matured fruits and therefore with the spreading calyces unusually prominent.

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† CHENOPODIUM PRATERICOLA Rydb. Narrows, Aug. 12, 1913, Lunell.

† ATRIPLEX PATULA L. Wahpeton, Aug. 6, 1919. Along a street by buildings. Dr. Standley, who examined a specimen, writes that this species is perhaps only a form of *A. hastata* L., but we seem to have no other specimens which would be referred to this form.

† SUCKLEYA SUCKLEYANA (Torr.) Rydb. Belfield July, 4, 1914.

CORISPERMUM

Following Standley's treatment of this genus (N. Am. Fl. 21: 79–80. 1916) I would place our material as follows:

C. hyssopifolium L. Mandan, *Wright 610*.

† *C. nitidum* Kit. Sandhills near Anselm, Aug. 21, 1918.

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POLYGONUM HYDROPIPER L. Hankinson, July 30, 1919. Lunell (Am. Mid. Nat. 5: 184. 1918) has referred the Ft. Ransom specimen to *P. punctatum leptostachyum* (Meisn.) Small, but it has dull akenes and flowers in the lower axils, as in *P. Hydropiper*.

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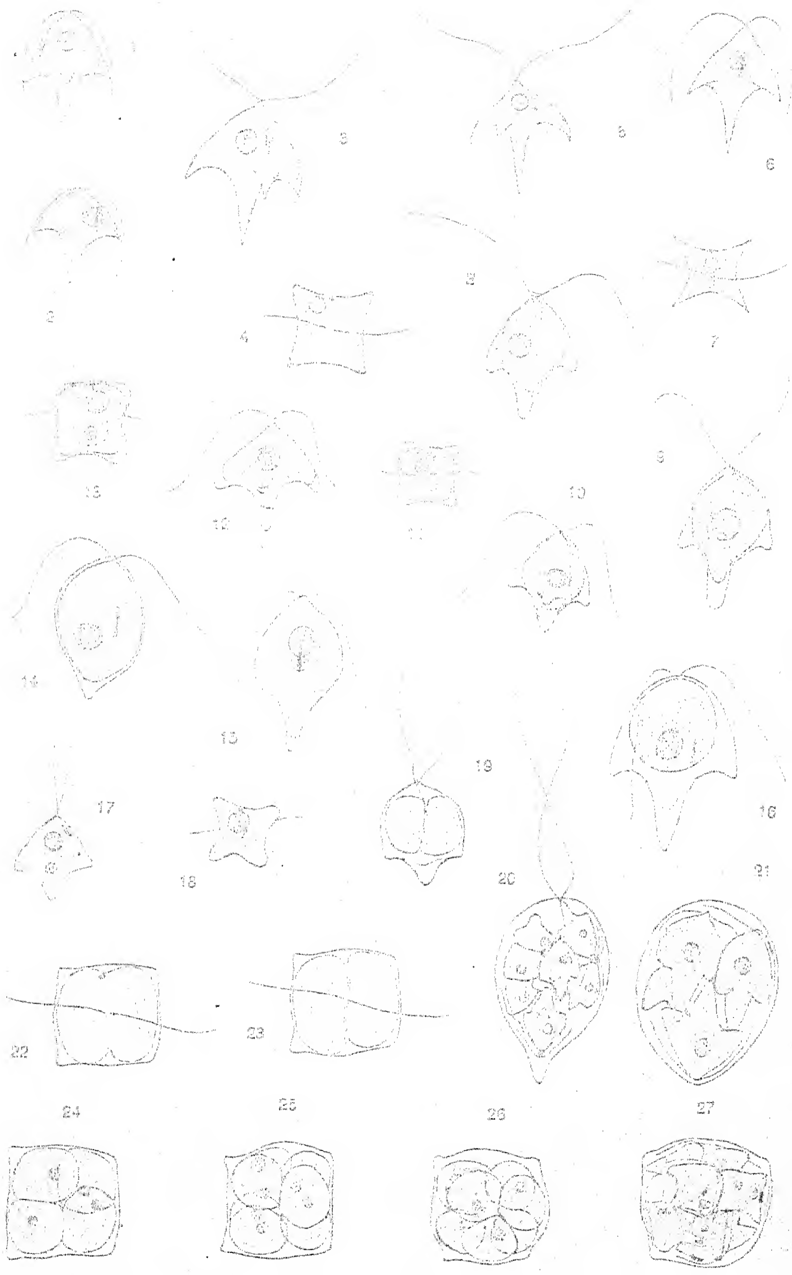

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ASCLEPIAS SYRIACA L. Westfield, July 16, 1919. This does not seem to be common so far west. The specimen reported

by Bergman from Morton County (*Bell 30*) is undoubtedly *A. speciosa* Torr.; it is sterile but has the characteristic pointed leaves of that species. The specimen reported by Bergman as possibly a hybrid of the two species seems scarcely different from *A. syriaca*.

† ASCLEPIAS PUMILA (A. Gray) Vail. Mr. W. W. Eggleston has examined our material of *A. verticillata* L. and refers the following to *A. pumila:* Esther, *Bell 542*; Fleak, *Bell 1370*.

† ACERATES LANUGINOSA (Nutt.) DC. Janesburg, *Bell 30*, of Bergman's catalogue should be referred to this species instead of to *A. viridiflora* Ell.

† VERONICA MARITIMA L. Kongsberg, Sept. 1918, *Fred Schmidt, Jr.* A few plants in a grove of planted trees. Determined by F. W. Pennell.

CUSCUTA ARVENSIS Beyr. The Logan County record is by Brenckle, Aug. 18, 1912. We have also the following records: McLeod, *Bell 385*: Valley City, July 26, 1913; Enderlin, Aug. 20, 1918. Dr. T. G. Yuncker, who has examined portions of the Logan County and Valley City specimens, writes that he would call them C. *pentagona* Engelm. The other specimens seem to be the form which he calls *C. calycina* Engelm. The former were growing upon plants of the dry prairie, while the latter preferred those of riverbanks and similar localities.

CUSCUTA GRONOVII Willd. Fargo, Aug. 14, 1890, *Waldron*, is the only specimen which I consider typical. When preparing my paper on *Cuscuta* (Am. Jour. Bot. **3**: 185–188. 1916) I was unable to find fresh material, but all that I have found at Fargo since that time agrees better with what I had called *C. plattensis* A. Nels. The habitat of *C. plattensis*, as stated by Nelson, hardly indicates this plant and I become doubtful of its identity. Dr. Yuncker writes me that an examination of the type of *C. plattensis* shows my plant to be quite different, although the description of the species as given by Nelson agrees. He refers my specimens to *C. Gronovii* var. *curta* Engelm. In a flax field at Ft. Ransom, where considerable damage was caused, this form and *C. Coryli* Engelm. were both present, sometimes separate and at others tangled together on the same host plant. The field was a small one next to the woods of the river.

PHLOX

Following the treatment of the western forms by E Nelson (Ninth Rept. Wyoming Agr. College, 1899), our plants would seem to be separated more satisfactorily as follows:

Leaves 5–10 mm. long; flowering stems one-flowered. *P. Hoodii.*
Leaves 1–2 cm. long; flowering stems two-to several- flowered: more upright, the bark peeling off in shreds. *P. andicola.*

PHLOX ANDICOLA (Britton) E. Nelson. *P. Douglasii* of Bergman's Flora, in part. This seems to be better separated from *P. Hoodii* Rich. by the above characters than by the size of the flowers. The Medora and Washburn specimens referred by Bergman to *P. Douglasii* Hook. are evidently *P. Hoodii.*

† LAPPULA CENCHRUSOIDES A. Nels. Marmarth, July 4, 1918, in sandy soil of river valley. Habit of growth similar to *L. occidentalis* (Wats.) Greene, nutlets similar to those of *L. Lappula* (L.) Karst. but larger, the spines longer, and with a row of elongated tubercles on the middle of the back of the nutlets. The following, previously referred to *L. Lappula*, also belong here: Medora, *Bergman 1276*; same locality, June 19, 1910; Williston, *Bell 25*.

† LAPPULA CUPULATA FOLIOSA (A. Nels.) Nels. & Macbr. Marmarth, same as preceding. Often three of the nutlets of a flower have the spines confluent, forming a spreading border, the fourth nutlet with simple spines. In the specimens collected, however, there seems a decided tendency for the spines to be simple on all nutlets of the lower flowers. There are also nutlets with spines of intermediate form, broadened but not united. Counts on three plants show nutlets as follows:

Plant No. 1—80 united, 71 simple, 40 intermediate;
Plant No. 2—61 united, 106 simple, 34 intermediate;
Plant No. 3—47 united, 47 simple, 14 intermediate.

The color of the corolla is an uncertain character, white flowers often appearing bluish in the dried specimens.

† LAPPULA TEXANA HOMOSPERMA (A. Nels.) Nels. & Macbr. Marmarth, same as preceding, occasional plants in patches of *L. occidentalis*, all plants dried up and only fruits collected. From a planting of fruits the following season about twenty-five plants of *L. occidentalis* were obtained from fruits of that species. No plants were secured from the few fruits of the other two species.

† LAPPULA FLORIBUNDA (Lehm.) Greene. Lake Ibsen (Leeds) July 4 and 17, 1914, *Lunell*; Pleasant Lake, June 29, 1920.

† CRYPTANTHA CALYCOSA (Torr.) Rydb. Bowman, June 23, 1918, in loose burned clay around large boulders of the same material.

AMSINKIA MENZIESII (Lehm.) Nels. & Macbr. *A. intermedia* F. & M. Rugby, July 7, 1917, and July 27, 1918, a number of plants along the railroad track near the station; the first collection in flower, the second in fruit. Bergman's specimen from Pembina is evidently this species also, instead of *A. lycopsoides* Lehm.

† LAMIUM AMPLEXICAULE L. Langdon, July 18, 1918, a quantity in a dooryard.

† DRACOCEPHALUM THYMIFLORUM L. Belfield, July 4, 1914, several plants in a field of *Bromus inermis*. Several other introduced plants were also in the field: *Potentilla argentea* L., *Campanula sibirica* L., *Chrysanthemum Leucanthemum* L. and *Bromus tectorum* L. To be consistent with Bergman's nomenclature this plant should perhaps be referred to *Moldavica* but I have not thought it desirable to make such a change at this time. The plant is different in appearance from *D. parviflorum* Nutt., being slender and having very small flowers.

† LYCOPUS COMMUNIS Bicknell. Pleasant Lake, July 26, 1912, *Lunell*; Anselm, Aug. 29, 1920 (common in alder swamps). The Anselm plant has been verified by P. A. Rydberg.

† SALVIA LANCEOLATA Willd. In fields. Carrington, Aug. 27, 1919; Mandan, Sept. 13, 1920.

CHAMAERHODOS ERECTA (L). Bunge. This was included in the seventh edition of Gray's Manual, the record being apparently based on a specimen collected near Crookston, Minn. (Minnesota Bot. Studies **2**: 584. 1901). I had thought that it might have been introduced in gravel as railroad ballast, but so far as I have been able to learn the locality mentioned is a gravel pit. It is probably one of the instances of a plains species occuring on the eastern edge of the Red River Valley. I have not seen the plant east of the hills along the Sheyenne River at Sheyenne and Valley City.

† CRATAEGUS MOLLIS T. & G. Fargo, May 26, 1917. One tree is in a thicket east of the fair grounds, and quite a number occur in a bend of the river two miles farther north.

† MEDICAGO FALCATA L. Oakes, July 18, 1919, a plant along the railroad tracks.

† ASTRAGALUS PARVIFLORUS (Pursh) MacM. Marmarth, July 3, 1918. Quite common on the higher parts of the hills.

† HEDYSARUM sp. Sentinel Butte, Aug. 0916, *Brenckle*, a single pod collected. Reported by Arthur (N. Am. Fl. **7**: 450. 1921) as *H. cinerascens* Rydb.

† EVONYMUS ATROPURPUREUS Jacq. Owego, Sept. 1916, *R. A. Shunk*.

† LOMATIUM MACROCARPUM (Nutt.) Cov. & Rose. Dunseith, May 18, 1918, *Lunell*, and fruits collected at Minot in June, 1910, seem properly referred to this species.

† SICYOS ANGULATUS L. I have seen a specimen collected by A. H. Shunk along the Sheyenne River near Anselm.

† CAMPANULA SIBERICA L. Belfield, July 4, 1914, a single plant found in a field of *Bromus inermis*.

† XANTHIUM PENNSYLVANICUM Wallr. A specimen in the Gray Herbarium from Leeds, Aug. 21, 1902, *Lunell*, is referred by Millspaugh and Sherff (Field Mus. Nat. Hist. Bot. Ser. **4**: 33. 1919) to this species. Some specimens of *Xanthium* collected along the river at Fargo in 1919, to show variations in burs, were determined by Sherff as *X. italicum* Mor. (*X. canadense* of the Flora) and *X. acerosum* Greene, † with the comment that the latter was perhaps not distinct.

† CHRYSOTHAMNUS NAUSEOSUS (Pall.) Britton. Williston, Aug. 11, 1915, on the hills along the Missouri River about fifteen miles southeast of the city. A plant of quite different appearance from *C. graveolens* (Nutt.) Greene, which is common there and on the buttes in the bad lands—the crown low, and with gray branches only 1–2 dm. long. This is the plant referred by Lunell (Am. Mid. Nat. **5**: 41. 1918) at my suggestion to *C. formosus* Greene, but it evidently is not that species.

HELIANTHUS GIGANTEUS L. The form referred to in Bergman's Flora under this name is quite common in the central (and western?) part of the state, but I am as yet in doubt as to its status. It is evidently Lunell's *H. nitidus* (Am. Mid. Nat. **1**: 235. 1914). Specimens from Valley City and New Rockford were determined by Standley as *H. tuberosus*. The Fargo specimens are *H. Maximiliani* Schrad.

HELIANTHUS GROSSE-SERRATUS Martens. The Fargo specimen of the Flora is certainly *H. Maximiliani*. The stem is only slightly hispid above and the leaves are broader and more nearly flat than usual. The Kenmare specimen (*Bergman 2744*) belongs to the preceding form.

† MADIA GLOMERATA Hook. Spring Brook, Aug. 17, 1915, a quantity in a prairie slough near the town.

† ARTEMISIA PABULARIS (A. Nels.) Rydb. Mandan, Sept. 11, 1020. Determined by Rydberg. There seems to be no other specimen among our material which resembles this. Mr. Thysell of the Northern Plains Station showed me the plants, only two places where they were growing being known.

† SENECIO MANITOBENSIS Greenman. Bottineau, July 8, 1917. Determined by J. Lunell. In the meadow of a dried up pond in the Turtle Mts.; Towner, July 13, 1911, *Lunell* (specimen in the Gray Herbarium).

† CENTAUREA PICRIS Pall. Spring Brook, Aug. 11, 1918. Determined by Standley. Received from Jacob Widman who referred to it as abundant in a field. Especially a few years ago the akenes were often found in Turkestan alfalfa seed, but this is apparently the first record of its having become established.

SONCHUS ARVENSIS L. Ellendale, July 24, 1919. Several spots around buildings in the town.

†SONCHUS ULIGINOSUS Bieb. *S. arvensis* of Bergman's Flora, Fargo, Aug. 1, 1916; Oakes, July 18, 1919; Crosby, June 7, 1919, *J. H. Phelps;* Williston, Aug. 1915. Specimens of this and of the preceding were examined by Standley, who stated that no North American specimens were in the U. S. National Museum collections. A specimen sent to the New York Botanical Garden was reported by Rydberg as apparently new to this country*. This seems rather strange in view of the fact that it is the common form through the Red River Valley, and westward in the northern part of North Dakota to somewhat beyond Devil's Lake, southern Manitoba, and western Minnesota. It is said to have first appeared at Portage Plains, Manitoba, about 1900.

This form differs from *S. arvensis* in the absence of glandular hairs on the upper stems and involucres. While I have not been able to compare carefully fresh material, I believe the heads are smaller, paler, and the rays more inclined to become recurved. Vegetative reproduction is by long horizontal roots and not rootstocks as commonly stated. The development of the terminal head is often stopped before flowering and several flowering branches arise just below it.

* Small has recently listed the species as an addition to the American flora, from Pennsylvania, where it was collected in 1921 (see Torreya **21**: 100. 1922).

LACTUCA VIROSA L. Many European authors describe this as having horizontal leaves and black, broadly margined akenes. This does not apply to our plants. The pinnatifid-leaved form is only occasional in the state (Kulm, *Brenckle 782*; Bottineau, July 23, 1918; Fargo, Aug. 17, 1920). Pammel's notes (Rhodora **20**: 180–181. 1918) on the replacement of the entire-leaved form by the pinnatifid in Iowa suggest that it will be interesting to watch for a similar case here.

† CREPIS OCCIDENTALIS Nutt. Bowman, June 23, 1918. Quite common on Twin Buttes.

† CREPIS CAPILLARIS Roth. Fargo, Aug. 26, 1920; Willow City, *F. M. Rich.*

† SPIRODELA POLYRHIZA (L). Schleid. Fargo, Aug. 30, 1919, a few plants among masses of *Lemna.*

† CYPERUS DIANDRUS Torr. Anselm, Aug. 1916, *R. A. Shunk.*

† CYPERUS ESCULENTUS L. Fargo, Oct. 2, 1920.

SCIRPUS VALIDUS Vahl. I cannot support Bergman's separation of most of our material as *S. occidentalis* (Wats.) Chase. There do seem to be two forms present, one with spikelets as figured in Gray's Manual (ed. 7, *f. 290*), the other with more rigid panicles and longer spikelets. The specimens, however, do not match Bergman's separation. Both of these forms were found in a small patch at Oakes on July 18, 1919, the first occupying a definite part of the patch. Specimens of each were identified by Agnes Chase as *S. validus.*

CAREX OBTUSATA Liljebe. Verified by Standley. Fargo, June 24, 1920. Quite abundant, at least in one place in low prairie. Kensal, *Bergman, 1744,* is alsothis in stead of *C. stenophylla* Wahlenb.

The following additional species of *Carex* were recorded by Lunell (Am. Mid. Nat. **3**: 234–237. 1916) from specimens determined by Mackenzie: *C. Hookeriana* Dewey, *C. athrostachya* Olney, *C. tenera* Dewey, *C. praticola* Rydb., *C. Emoryi* Dewey, *C. scirpiformis* Mackenzie, *C. Parryana* Dewey, *C. laeviconica* Dewey and *C. atherodes* Spreng.

† SYNTHERISMA SANGUINALE (L.) Dulac. Fargo, Oct. 2, 1920.

† PANICUM PERLONGUM Nash. Verified by Hitchcock. Fargo, June 24, 1920. Very abundant in one place in low prairie.

† SPOROBOLUS ASPER (Michx.) Kunth. Mayville, Aug. 21, 1919: Fargo, Aug. 16, 1920; Steele, Sept. 10, 1920.

FESTUCA VIRIDULA Vasey. Lunell (Am. Mid. Nat. 4: 224 1917) has reported this species from Dunseith. I have examined carefully a specimen received from him ("det. by U. S. Dept. Agr.") but can see no reason why it should not be referred to *F. Hallii* (Vasey) Piper.

BROMUS JAPONICUS Thunb. Fargo, Oct. 1918. Determined by Agnes Chase. All of the specimens referred by Bergman to *B. commutatus* Schrad., and several others not reported, seem to belong here.

† LOLIUM RIGIDUM DUTHIEI Hook. Determined by Agnes Chase.

Annual: culms 3 to 4 dm. high, rather stiff, somewhat scabrous above; leaves upright, 5 mm. wide, 1 dm. or more long, glabrous or nearly so; glume about three-fourths as long as the well developed spikelets, equalling the younger or shorter ones; spikelets five- to seven-flowered, the larger 2 cm. long; lemmas 8 to 10 mm. long bearing an awn 7 to 12 mm. long.

Described from a specimen collected July 7, 1919, grown from seeds found in a sample of wheat from the northeastern part of the state. An early maturing annual, not so large as *L. temulentum* L. and quite different in the longer, lanceolate, awned florets. The culms commonly bear a branch from the first node, some of these in the specimen cited being only 1 dm. long with spikes barely protruding. The Milton specimen cited by Bergman under *L. temulentum* belongs here, both it and plants from the 1919 culture having been examined by Mrs. Chase. The plant seems well established in that vicinity as evidenced by these cases, by material received at one or two other times and by seeds found in several samples of wheat.

† LOLIUM REMOTUM Schrank. In flax plots, Mandan, 1918.

AGROPYRON

Three species of this genus are of great economic importance in North Dakota. Having had occasion to pay particular attention to these, I find that as a rule, descriptions and figures seem to have been made from immature material, causing certain characters to be overlooked. The spikelets are well figured by Hillman (Bur. Pl. Ind., U. S. Dept. Agr. Circ. 73. 1911). I offer the following descriptions:

A. repens (L.) Beauv. Spikelets distinctly articulated to the rachis (so that they break away readily, with a rounded base), and with a strong transverse impression about 1 mm. above the base. Glumes from half as long to nearly equalling the spikelet, strongly nerved, with about a dozen short teeth on the keel* near the apex which is acute or obtuse, often bearing an awn 2–10 mm. long; margins of the glumes thin and translucent except toward the base where they are indurated, rounded, usually slightly separated exteriorly and quite widely interiorly.

A. Smithii Rydb. Spikelets not articulated (breaking away with a rough base) and only slightly impressed. Glumes about one-half as long as the spikelets, indistinctly nerved and without distinct teeth on the back; margins thin on lower third (meeting exteriorly), abruptly narrowed to a long stiff, acuminate point.

A. tenerum Vasey. Spikelets not articulated and only slightly impressed. Glumes about equalling the spikelets, acute, strongly nerved, the nerves all rough with small teeth, margins nearly straight.

† AGROPYRON DASYSTACHUM (Hook.) Scribn. A specimen from Bottineau, July 7, 1920, is referred here ("form which has been called *subvillosum*") by Hitchcock. Bowman, June, 30 1918, and Kenmare, July 15, 1913, are the same, and I think all the specimens previously referred to *A. molle* (excepting perhaps *Bell 385*) belong here.

† DRYOPTERIS THELYPTERIS (L.) A. Gray. Anselm, *R. A. Shunk*.

† DRYOPTERIS SPINULOSA (Retz.) Kuntze. Another specimen of the same collection as the preceding seems to belong here, as does also Walhalla, *Bergman 2000*.

Since the above was written I have received from Mr. F. P. Metcalf a reprint of an article (Jour. Washington Acad. Sci. **10**: 188–198. 1920) in which he reports eighteen additional species for the state. Several of the records suggest the probability of an error of indentification or of a difference in interpretation. In reply to my inquiry regarding a few of them Dr. Standley wrote that he has been able to find but one of the specimens, *Rumex Britannica* L. (McLean County), and that that seemed to be correctly determined.

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* This is not actually the central nerve, the broader part of the glume being exterior and only one or two nerves on the side next the rachis.

Three new species of Cuscuta from Mexico

T. G. YUNCKER

(WITH THREE TEXT FIGURES)

In studying collections of *Cuscuta* from Mexico three species have been discovered which, it is believed, have not been hitherto described. Descriptions of these new species, together with camera lucida sketches, are given below. With the addition of these the number of species of *Cuscuta* now known to occur in Mexico is thirty-six.

Cuscuta dentatasquamata sp. nov.

Stems medium to slender. Flowers reddish, 3–4 mm. long, on pedicels shorter than or mostly about equal to the flowers, in rather compact, cymose clusters; calyx deep, lobes exceeding the corolla tube, triangular, acute, slightly overlapping at the base, thickened in the median region, forming a small carina on most of the lobes; corolla campanulate, lobes triangular, acute, upright or spreading, shorter than the tube and with slightly uneven margins; stamens shorter than the corolla lobes, filaments stoutish and about equal to the oval or orbicular anthers; scales about reaching the stamens, dentate, with

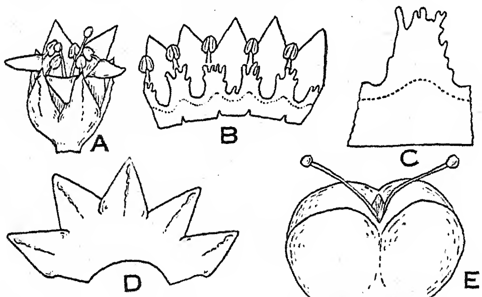

FIG. 1. CUSCUTA DENTATASQUAMATA Yuncker
A. Flower, × 5. B. Opened corolla, × 5. C. Individual scale, × 10. D. Opened calyx, × 5. E. Capsule, × 5.

few processes, bridged at about the middle, not firmly adherent to the corolla; styles slender, about equal to, or longer than, the depressed-globose ovary. Capsule large, depressed-globose, thin, somewhat irregularly circumscissile, carrying the withered corolla about it; seeds about 1.5 mm. long, globose, two to four in each capsule, hilum oblong, transverse.

This species falls in section EUGRAMMICA, subsection LEPTILOBAE, near *Cuscuta Choisiana* Yuncker. It differs from that

species, however, in the color of the flowers, and in the shape of the scales and of the calyx and corolla lobes. It superficially resembles *Cuscuta partita* Choisy, but differs from that species in possessing shorter corolla lobes, dentate scales, shorter filaments and larger flowers.

The only specimen examined was from Los Pinitos, Sonora, Mexico (*Hartman 119*), the type, in the Gray Herbarium.

Cuscuta cozumeliensis sp. nov.

Stems rather coarse. Flowers 4–5 mm. long, on pedicels about as long as, or shorter than, the flowers, in cymose clusters; calyx shorter than the corolla tube, lobes ovate-orbicular, overlapping, somewhat fleshy toward the base, margins very uneven; corolla campanulate, lobes much shorter than the tube, erect or spreading, overlapping, obtuse or rarely slightly acutish, margins uneven; stamens shorter than the lobes, filaments stoutish, about equal to, or slightly longer than, the oval anthers; scales not reaching the stamens, oblong, moderately fringed

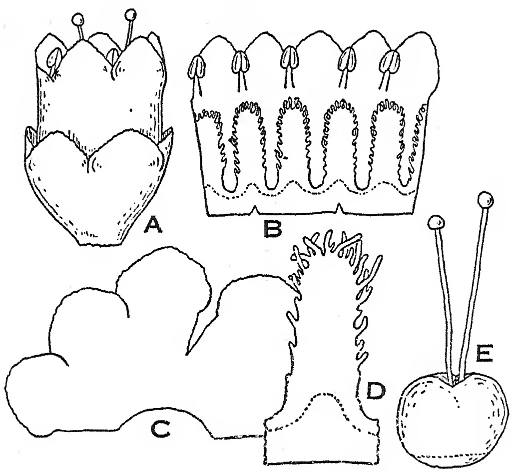

FIG. 2. CUSCUTA COZUMELIENSIS Yuncker

A. Flower, × 5. B. Opened corolla, × 5. C. Opened calyx, × 5. D. Individual scale, × 10. E. Ovary, × 5.

with medium length processes, bridged at about a quarter of their height; styles slender, much longer than the depressed-globose ovary. The only specimen seen of this species is fragmentary and not ripe enough to show capsules. The ovary, however, gives indications that the capsule would be definitely circumscissile and probably carry the withered corolla about it.

This species falls in section EUGRAMMICA, subsection OBTUSILOBAE, near *Cuscuta macrocephala* Schaffner, from which it differs in the stamens not being sessile as they are in that species, and in having smaller stigmas and longer processes on the scales.

It might be confused with *Cuscuta floribunda* H. B. K., from which it differs in having shorter corolla lobes and shorter scales; with *Cuscuta corymbosa grandiflora* Engelm., from which it differs in the corolla not bulging between the filament attachments and with broader scales; and with *Cuscuta tinctoria* wartius, from which it differs in its larger flowers and proportionately shorter corolla lobes and shorter scales.

The specimen examined was from Cozumel Island, Yucatan, Mexico (*Gaumer 90*), the type, in the Gray Herbarium.

Cuscuta durangana sp. nov.

Stems slender. Flowers membranous, about 2 mm. long, on pedicels mostly as long as, or longer than, the flowers, in cymose panicles; calyx about as long as the corolla or scarcely reaching the sinus; lobes ovate, obtuse or, rarely, acutish, not overlapping; corolla campanulate; lobes ovate, obtuse, spreading, later becoming reflexed, about as long as the tube; stamens shorter than the lobes, the large, oval, versatile anthers about equal to the stoutish filaments; scales about reaching the stamens, obovate or spatulate, fringed about the upper half, bridged low; styles slender and longer than the globose ovary. Capsule depressed-globose, circumscissile, carrying the withered corolla about it; apparently mostly two-seeded; seeds ovate, slightly rostrate, about 1.5 mm. long, hilum oblong, oblique.

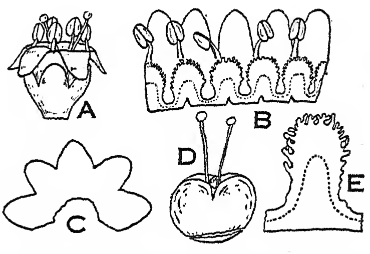

FIG. 3. CUSCUTA DURANGANA Yuncker A. Flower, × 5 B. Opened corolla, × 5 C. Opened calyx, × 5. D. Capsule, × 5. E. Individual scale, × 10.

This species falsl in section EUGRAMMICA, subsection OBTUSILOBAE, near *Cuscuta applanata* Engelm. It differs from this species, however, in having longer pedicels and a looser inflorescence and in not exhibiting keels on the calyx. It superficially resembles *Cuscuta umbellata* H. B. K. The obtuse corolla and calyx lobes easily distinguish this species, however.

The only specimen examined was from Durango, Mexico (*Endlich 268*), the type, in the herbaruim of the Botanical Institute at Dahlem (a small bit in the writer's herbarium).

DEPAUW UNIVERSITY

INDEX TO AMERICAN BOTANICAL LITERATURE
1908-1921

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to foresty, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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BULLETIN

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New British and American species of Lobomonas: a study in morphogenesis of motile algae

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(WITH PLATES 5 AND 6)

The genus *Lobomonas* was established in 1899 by Dangeard (3) on a single species, *L. Francei*, found somewhat frequently in the vicinity of Poitiers, France. This species had been figured twenty-one years previously by Stein (7, *pl. 13, f. 17, 18*) as a form of *Chlamydomonas pulvisculus* Ehrenb. Golenkin also appears to have had this species in Russia, and to have confused it with another genus, for one of his figures (5, *f. 19*), described as a reduced form of *Pteromonas alata* (Cohn) Seligo, can hardly be anything else than a young cell of *L. Francei*. Apparently the species has not been studied or scarcely even reported otherwise, except by Dangeard. In 1902 Chodat (2) transferred to the newly founded genus his species *Chlamydomonas stellata*, briefly described six years before (1); he even appears to have been doubtful of the distinctness of his form from Dangeard's type, though both species have been accepted by West (8, p. 172) and Wille (9, p. 19), who have reproduced the original illustrations.

The genus presents a cell organization almost precisely like that of *Chlamydomonas*, probably its nearest relative, with the exception that its outer wall is furnished with variable irregularities or protuberances, which in the type species are frequently more developed on the posterior part of the cell, while in *L. stellata* the more uniformly triangular lobes are figured as covering the wall nearly to the region of insertion of the cilia. It

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is probable that *Lobomonas* has escaped the notice of collectors to some extent because of the minute size of the cells, but doubtless it is actually one of the rarest genera of the *Chlamydomonas* group. The two new species now presented serve to emphasize the unity and distinctness of the genus, and also provide certain features of division and conjugation not known hitherto, which indicate a fundamental parallelism with *Chlamydomonas*.

Lobomonas pentagonia sp. nov.

This species, the first of the genus to be reported in England, I believe, was discovered in considerable abundance, together with two species of *Pteromonas*, at Ham Common, Surrey, near Kew, in 1920. The habitat was the border of a small shallow pond at the west end of the common, a place frequented by cows and horses, and therefore supplied with water containing a considerable amount of nitrogenous organic matter in solution: in fact the general conditions were very like those of the much smaller pool where *Lobomonas rostrata*, to be described presently, was found with another species of *Pteromonas* in New Jersey.

Like all other species of the genus, *L. pentagonia* is very minute, but it is more constant in form than *L. Francei* or *L. rostrata*. When seen in side view the cell appears rather pentagonal in outline (FIGS. 1–4), but careful focussing shows that the angles do not all lie in the same plane. Polar views often show five to eight protuberances (FIG. 14), likewise not all at the same level. One of the most symmetrical specimens, when resting with its ciliated end turned upward, shows four anterior protuberances and, alternating with them, four others at the posterior end of the zoospore (FIG. 5); the number, however, is variable. The protoplast, including the chromatophore, in young individuals usually extends into and fills the protuberances, and ends anteriorly in a somewhat obtuse beak, to which the two cilia are attached (FIG. 1). In older specimens the protoplast usually retracts from one or more of the wall protuberances and leaves them empty: they do not appear like dense gelatinous structures. The chromatophore is more or less hollowed out in the common *Chlamydomonas* fashion but thickened in the region where the pyrenoid lies in a somewhat lateral position. The two alternately pulsating vacuoles lie in a plane nearly perpendicular to that passing through the two extended cilia (FIG. 5), as in most species of *Chlamydomonas*, so that in the ordinary face view of the cell only one is usually seen. The

narrow rod-shaped red eye-spot lies in or just beneath the plasma membrane slightly in front of the middle of the cell. Its position with relation to the cilia is more like that which it occupies in *Brachiomonas* than that in *Chlamydomonas*, as brought out recently by the writer (6), though the dorsiventral differentiation here is perhaps less constant and definite than in the two related genera.

ASEXUAL REPRODUCTION. Dangeard (3) reports that his attempts to cultivate *L. Francei* in a moist chamber did not succeed, and that it was difficult to obtain the multiplication of the organism. He shows that the cells come to rest and generally become rounded in shape, then divide into four or eight daughter cells which escape as zoospores. He gives no figure to support Wille's (8) surmise that division is longitudinal. In our two new species I found that very generally after motile cells were mounted in a hanging drop they would for the most part come to rest in a few hours and proceed to divide, though in many cases the daughter cells failed to become motile or escape. In both species pyrenoids were not seen in any dividing specimens until the daughter cells had begun to take on the typical form, so that it would appear necessary to conclude that in this genus, as in *Brachiomonas* and in some species of *Chlamydomonas*, the pyrenoid disappears before the first cleavage, and that one is formed *de novo* in each daughter cell.

In *L. pentagonia* the first division plane usually appears at first sight to be transverse to the longitudinal axis of the cell, but several cases were observed which lead to the conviction that there is regularly a rotation of the protoplast during or before the beginning of cleavage. FIGS. 6 and 7 show two stages of division where the protoplast has revolved to an oblique position when the cleavage begins; probably the rotation was delayed more than usual in this case; here the original contractile vacuoles persist after the division of the nucleus. Fig. 8 shows a case where what I am sure the original vacuoles persisted until the end of cleavage into two daughter cells. In case of the formation of four zoospores the second plane of cleavage is perpendicular to the first, *i. e.* it lies in a longitudinal axis of the mother cell: it may lie in a single plane through the two halves (FIG. 11), or the second division plane in one half cell may be perpendicular to that in the other (FIG. 12).

SEXUAL REPRODUCTION apparently has not been observed hitherto in this genus. I considered it good fortune, therefore, to discover three or four cases of conjugation taking place almost simultaneously in one hanging drop. The gametes have the general form and character of the vegetative cells, but are much smaller, provided with an excessively delicate cell wall, and the cilia are longer than the cell body. In the first case seen, one gamete was rather broad and pillow-shaped, with a distinctly visible cell wall, while the other was narrower and probably more nearly cylindrical, and furnished with a wall so delicate that it was detected only in its subsequent behavior. The two gametes became engaged by their cilia, but not otherwise in contact, and remained in this position for at least a half hour, with slight dancing movement (FIG. 15); the cilia, most if not all of this time, were trailed backward along the sides of the narrower gamete. The first movement toward joining was in a sudden break of the anterior papilla of the broad gamete, whereby a broader papilla of colorless cytoplasm surged forward and presently plastered itself on the beak of the unchanged gamete (FIG. 16), the remainder of the protoplast of the broader gamete then distinctly withdrawing from the posterior part of its wall (FIG. 17). Now for a period of about a half hour the remainder of the protoplast of the broader gamete was gradually oozing out of its wall and into the narrower gamete: even yet the narrower gamete hardly showed a wall, but it seemed evident that one must be present, since the posterior part of this gamete rigidly retained its original form (FIGS. 19, 20). After this point more active ciliary movement carried the zygote beyond possibility of observation.

A second case showed a similar figure of the narrow gamete remaining rigid for as long a time as it could be followed. In all probability this wall of the narrow gamete is finally thrown off separately, permitting the rounding up of the plasmatic mass to form a spherical zygospore. A third case showed the gametes more nearly equal, and it was clear that the walls of both were practically alike in character and not easily abandoned (FIG. 21), so that fusion was long delayed.

There is in this species apparently little differentiation between the gametes; indeed one might be inclined to regard the difference in size as merely accidental. Nevertheless from the behavior of the cilia, that is, both pairs for the most of the time stretching back alongside the narrower gamete, one may assume

a certain degree of differentiation. The conjugation of this species presents a close parallel to that described by Goroschankin for *Chlamydomonas reticulata* (**5**, p. 126, *pl. 3, f. 6–8*). He states that the gametes show little difference in size, and that they sometimes simultaneously slip out of their walls; but more frequently, after the beginning of conjugation, one of the gametes first throws off its wall and takes on a globose form, then the second does likewise, and then the two rounded masses go on to complete fusion.

The subjoined Latin diagnosis presents the chief characteristics of this species:

Lobomonas pentagonia sp. nov. *L.* cellulis vegetativis minutis, membrana a latere aspectata forma aliquanto pentagonia sed angulis rotundatis (verrucis) haud omnibus in eodem plano a vertice aspectata rotundata cum 5–8 verrucis, aliis anterioribus, aliis posterioribus protoplasto vel membranae conformali vel plus minus contracto et ellipsoideo, cum rostello conico ad quod cilia bina cellulae longitudinem fere adequantia affiguntur; chromatophoro excavato, pyrenoidem unum sublateralem portante, et in parte excavata nucleum lateralem includente; stigmate bacilliformi paululum ante mediam cellulam sito; vacuolis contractilibus binis in rostello cytoplasmatico positis.

Propagatio fit 2 aut 4 zsooporis intra cellulae matricalis membranam ortis, divisione priore visa quasi transversaria propter protoplasti rotationem sed vero longitudinali.

Generatio fit gametis parvulis, vel subaequalibus vel aliquanto disparibus, membrana tenuissima vestitis, inter se binatim copulantibus.

Longit. cell. veg. 10–13 μ; lat. 9–10 μ. Longit. gametarum ca. 8 μ; lat. 4–5 μ; longit. ciliorum ca. 13 μ.

Hab. in stagni margine. Ham Common, Surrey, England, 1–7 Aug. 1920.

Lobomonas rostrata sp. nov.

This form, the first representative of the genus to be reported in America, at first sight appeared very similar to *L. Francei* Dangeard (**3**, p. 115), but careful study disclosed differences as important as those which distinguish most species of *Chlamydomonas*, so that I feel obliged to regard it as a new species. I first found a few individuals in examining a collection of *Gonium pectorale* and an undetermined species of *Chlamydomonas*, obtained the last of September, 1919, from a rain-water pool of a highway in the southern part of Englewood, New Jersey. Later it was interesting to discover that the species had been collect-

ed about a week earlier in a much deeper pool, about half a mile distant from that just mentioned; this discovery was due to the fact that a fine colony of the *Lobomonas* developed on an agar plate containing a sample of my first collection of *Pteromonas* from this pool. The new species continued to appear sporadically in later gatherings from the same pool, the last being made November 12; it was also collected in October, together with *Chlamydomonas metastigma* Stein, from another rain-water pool in a wheel-rut, not far from the one first mentioned, though separated from it by railroad tracks bordered by a deep ditch on either side. The first mentioned wheel-rut yielded a few individuals in the following season. A few specimens of this species were also discovered during the past summer in a collection from a similar wheel-rut in northern Vermont: here it was accompanied by *Gonium pectorale*, *Pandorina*, *Chlorogonium*, *Chlamydomonas*, and a very interesting new form of *Polyblepharides*, to be described in a forthcoming paper. The *Lobomonas* never appeared to be abundant like its associates in the same pools; usually not more than a dozen or two specimens turned up in one hanging drop mount.

The vegetative cells or zoospores of this species most commonly have a somewhat obpyriform shape (FIG. 22–27) though they are sometimes almost ellipsoid. In younger individuals the cell wall is so delicate and close-lying as to be indistinguishable for the most part, but in older cells it is well developed (FIGS. 28, 29); it is generally produced into a variable number of lobes, of which from five to seven or sometimes as many as ten appear in a face view; that these lobes are developed on all sides of the cell is clearly shown in a polar view (FIG. 30). At the anterior, usually broader end, the wall is extended into a truncate, wedge-shaped beak, or possibly more typically this takes the form of a more or less double papilla (FIG. 33); on account of the minute size of the organism it is often most difficult to see clearly the exact structure of this protuberance, which is one of the most characteristic features distinguishing this species from the two hitherto described in Europe. Sometimes the wall appears to be uniformly thin, sometimes thickened at the end of the lobes, and sometimes considerably thickened throughout. The protoplast, indistinguishable outwardly from the bright green chromatophore, fills the lobes in young individuals; in older cells it retracts more or less, so as to leave some or all of the lobes colorless. In such cases it is not easy to determine whether the

lobe is a dense, gelatinous structure, or simply membranous and separated by a space from the protoplast. In certain cases the latter interpretation is clearly indicated, for the tip of the lobe is manifestly of thickened grayish wall substance, with a clear space inside (FIG. 37). The cilia are attached at a single point to the anterior end of the protoplast, which is usually obtuse, though it may have a slight beak; they immediately diverge at a wide angle to pass separately through the papilla of the wall, and are often seen in quiescent individuals stretching out stiffly in the form of a v; their length is as variable as the cell outline, often being less than the cell length, but perhaps more characteristically distinctly greater than the cell length. At the base of the cilia are the alternately pulsating vacuoles, lying regularly in such a position that a line passing through the two is perpendicular to the plane in which the quiescent cilia lie, so that only one of the vacuoles is seen when both cilia are equally clear, but both may appear at the same level when one of the cilia is behind the other (FIG. 29). The single pyrenoid occupies a lateral position in the deeply hollowed out chromatophore (FIGS. 24, 26), contrasting sharply with the axial pyrenoid in a massive chromatophore described and figured by Dangeard (3) in *Lobomonas Francei.* The small rod-shaped red eye-spot lies in front of the middle of the cell, but apparently not in a constant position with reference to planes passing through the cilia and contractile vacuoles, as is the rule in *Pteromonas* and in many species of *Chlamydomonas.*

REPRODUCTION. The earliest stages of division found presented the appearance of a cleavage transverse to the longitudinal axis of the cell. More careful consideration, however, here, as in *L. pentagonia*, indicates that an early rotation of the protoplast has eluded observation, for in FIG. 36 two contractile vacuoles, lying in what appears to be the original colorless anterior cytoplasm, now appear on the side of the cell. Even in such a case as that shown in FIG. 37, there is a colorless central region which can only be explained on the supposition that the anterior end of the protoplast had revolved ninety degrees from its original position, here not clockwise as in FIG. 36, but in a vertical plane with reference to the observer. The mother cell retains very much of its original form throughout the process of division, instead of rounding up, which Dangeard describes as being the general rule for *L. Francei.* Here also there may be four or eight daughter cells formed, and they regularly show the

typical obpyriform and lobed shape, and sometimes even show the protoplast somewhat separated from the new cell wall, before escaping from the mother cell. The escape appears to be accomplished by a gradual softening and disintegration of the wall of the mother cell, rather than by rupture at a single point (FIG. 40). The eight daughter cells of this figure are so small as to occasion the surmise that they might be gametes, but conjugation was not seen in this species.

The chief characteristics distinguishing this species from *L. Francei* Dang. are: the general obpyriform shape, the well developed anterior beak or papilla, the lateral pyrenoid, and the persistence of the form of the mother cell during division. The description may be summarized as follows:

Lobomonas rostrata sp. nov. *L.* cellulis vegetativis plus minusve obpiriformibus, rarius ellipsoideis; membrana cellulae in verrucas plures quarum 5–7 vel etiam 10 in facie una apparent producta, atque in polo anteriore rostello cuneiformi seu papilla subduplici instructa, per quod rostellum procurrunt cilia bina longitudine corpus cellulae adaequantia vel longiora, vel breviora: protoplasto primum membranae verrucas complente, deinde plus minus contracto et ellipsoideo: chromatophoro valde excavato, pyrenoidem unum lateralem portante: stigmate baciliformi, paullulum ante mediam cellulam sito: nucleo majore nunc paene centrali, nunc laterali, rarius posteriori; vacuolis contractilibus binis juxta papillam anteriorem suppositis.

Propagatio fit protoplasto cellulae vegetativae jam immobilis diviso in 4 aut 8 zoosporas, quae formam typicam priusquam evaderunt ex cellulae matricalis membrana adipiscuntur. Copulatio haud observata.

Longit, cell. veg. 5–12 μ; lat. 4–8 μ; long. ciliorum ca. 5–14 μ.

Hab. in aqua pluviali quae colligitur in viis terrenis, et in lacuna quadem lutulenta in pascuo pecuario. Englewood, New Jersey, Sept.–Nov. 1919, Sept. 1920: Shelburne, Vermont, 3 Aug. 1921.

It has been already pointed out elsewhere (6) that *Lobomonas* is to be regarded as a special offshoot from *Chlamydomonas*, not leading to any higher group so far as we know at present. It might be thought simple to derive the genus directly from the Polyblepharidaceae, even from the genus *Dunaliella*, which clearly appears to be the immediate ancestor of *Chlamydomonas*, since it has all the features of cell organization of the latter genus except for the lack of a firm cell wall. When, however, it is recalled that the gametes of *Lobomonas*, reported above for the first time, possess cell walls, it will be more natural to look for

its ancestry among those species of *Chlamydomonas* which posses walled gametes, and are therefore ranked as the primitive members of the genus, since their vegetative cells and gametes differ (visibly) only in point of size. Our two new species of *Lobomonas*, moreover, also resemble a number of the relatively primitive members of *Chlamydomonas* in their method of cell division, namely through a cleavage which is fundamentally longitudinal but early shifts to a transverse position. The question then arises, what influences led to the divergence of cell form, which is practically the sole basis of separation between the species forming the small genus *Lobomonas* and the much larger number comprised in *Chlamydomonas*.

A CONSIDERATION OF MORPHOGENESIS IN PRIMITIVE ALGAE

This whole problem of the origin and inheritance of cell form in primitive organisms is one of very great interest which has received comparatively little attention. Perhaps the most extended discussion of the question has been furnished by D'Arcy Thompson (22), who regards surface tension as the paramount factor in the determination of cell form. Though at one point he admits that 'the physical cause of the localized inequalities of surface tension remains unknown', and at other times hints that an internal chemical heterogeneity may have some influence in connection with such differences in surface tension, nevertheless again and again he reiterates his main thesis in regard to unicellular organisms, 'that not only their general configuration but also *their departures from symmetry* may be correlated with the molecular forces manifested in their fluid or semi-fluid surfaces'. This explanation seems to us entirely inadequate and not in harmony with the general weight of evidence. For the particular organisms considered here and in the previous paper on *Brachiomonas* (6) we can offer little direct evidence; but there are certain facts which suggest that the conception of the non-homogeneity of the protoplasmic structure of the cell, as developed by Rhumbler (19) and Harper (12) supplies a much more workable hypothesis than the idea of mere surface tension forces.

Passing over Rhumbler's work on protozoa, the most thorough treatment of morphogenesis within a small group of primitive plants is found in the studies of Harper (11, 12) on *Pediastrum*. He believes that the general four-lobed form

of the cells familiar in most species of *Pediastrum* may well have arisen in evolution as a consequence of the pressure and contact relations of the young cells in the sixteen-celled colony, regarding them merely as surface tension globules: nevertheless he has shown repeatedly that this four-lobed form does not depend in ontogeny upon the forces which may have been responsible for it originally, but that it is inherited and may reach full expression when there is the least possible contact with other cells of the colony. Repeatedly Harper calls attention to the view that though surface tension is commonly acting as a morphogenetic factor, nevertheless 'it is the inherited anomogenous consistency of the cells which is of most significance in determining their form.' In strictly unicellular organisms like *Lobomonas* and *Brachiomonas*, there is an absence of the interaction of contact and pressure stimuli which are important influences in the variation of the *Pediastrum* colony; nevertheless in the fundamental organization of the cell the factors must be parallel in the main. In both cases the lobed form may be regarded as adaptive for the general metabolism of the cell. In *Pediastrum* the development of spines is usually looked upon as a case of primitive differentiation for protection, and in *Lobomonas* and *Brachiomonas* the lobes might easily be conceived of as subserving a similar function: in point of fact, I have observed that when these forms are found in the same pools with smooth-walled ovoid *Chlamydomonas* cells, it is the latter that are devoured by protozoa, while they rarely or never prey upon the lobed forms, even though the latter are smaller. However, when two species of *Chlamydomonas* are present together, sometimes one is rapidly consumed by protozoa while the other is ignored. The anti-selectionist, moreover, might fairly inquire why it is that these genera of bizarre form have produced very few species, in comparison with the extraordinarily successful genus *Chlamydomonas*, which has attained well nigh three score species, so far as taxonomy goes, in recent years.

Wille (9, p. 19) ascribed to the zoospores of *Lobomonas* the characteristic of 'deutliche Metabolie.' I cannot find that Dangeard uses this term in connection with this genus; but as defined by him elsewhere* as amoeboid movement, or used

*On désigne sous le nom de métabolie une sorte de mouvement par contraction du corps particulier à quelques Euglènes, Amibes, Monades, etc. C'est ce que nous appelons mouvement amiboïde. [Dangeard: Recherches sur les algues inférieures. Ann. Sci. Nat. Bot. VII. 7: 144. 1888.]

more exactly by other recent writers (especially in connection with the Polyblepharidaceae) in the sense of euglenoid or amoeboid change of form—and this was the usage of Perty*, by whom the word appears to have been coined in 1852—the term is misleading when applied to *Lobomonas*: or at least it can be used only in a very restricted sense in connection with this genus. The young cells of *Lobomonas* of course do undergo a certain change of outline during the formative process within the wall of the mother cell: ordinarily essentially the mature form is acquired and fixed before their escape, and I have found no evidence that it is appreciably altered afterward during activity, though, in appearance only, the mature cell may be distinctly reminiscent of *Amoeba*. Nevertheless, this idea of amoeboid change of form is most suggestive in a discussion of the formative period of such genera as we have under consideration, and for this restricted period I believe we are entirely justified in drawing a parallel with the results of certain recent researches on the production of pseudopodia.

A brief survey of this work may be useful in this connection. McClendon (16) has attempted to explain amoeboid movement as due to local increase in permeability, the *Amoeba* simply receding from the side on which the permeability has been increased. Its author himself admits the difficulty of explaining positive reactions by this theory, and it certainly does not offer any sufficient explanation for the assumption of the characteristic cell-form shown by our developing chlamydomonads. The closely related hypothesis that production of pseudopodia may be accounted for by local variation in surface tension has been widely invoked. The re-statement of this theory lately made by Thompson (22) may here be passed over, even as this stimulating writer has all but ignored the evidence which has been accumulating against the surface tension explanation. Both the permeability idea and the surface tension explanation as ordinarily employed are objectionable, in that they depend too

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*Metabolie. Hirunter verstehe ich die durch *innere Vorgänge* bedingte wechselnde Gestaltänderung. Seit langem bei den Amiben bekannt ist sie bei den Infusorien so viel als nicht beachtet worden. [Perty: Zur Kenntniss kleinster Lebensformen, p. 127. Berne. 1852.]

Since this term Metabolie seems to be unfamiliar to American botanists because of its very restricted usage, and since it has even been rendered as equivalent to metabolism in a recent German-English dictionary for chemists, it appears to be worth while to call attention to this original definition.

much upon external environmental influences to account for the requisite local variability, though this element is not necessarily involved in either theory.

The beginning of the more recent undermining of the surface tension explanation of form change is found in the work of Jennings (**14**), who from painstaking direct observation reported that the currents in a moving *Amoeba* as a whole 'are not similar to those of a drop of inorganic fluid that is moving or elongating as a result of a local increase or decrease in surface tension', and in particular that 'the movements of material in a forming pseudopodium are not like those in a projection which is produced in a drop of inorganic fluid as a result of a local decrease in surface tension'. From these observations Jennings was forced to the conclusion 'that changes in the surface tension of the body are not the primary factors in the movements and reactions of *Amoeba*'. Similar conclusions from direct observation were announced two years later by Dellinger (**10**), whose clever photographs of *Amoeba* viewed from the side reveal the locomotion of the organism as a sort of 'walking,' rather than a flowing of a fluid substance upon the substratum. These negatory conclusions have been reinforced and extended by a series of recent researches in the field of microdissection (**15, 21, 13**). From these there is general agreement that the structure of *Amoeba* (and probably of many other rhizopods and cells of primitive organization) is not of the nature of a simple fluid mass governed chiefly by surface tension forces, but rather that it is a highly non-homogeneous system, consisting of comparatively fluid endoplasm surrounded by an ectoplasm which has often the character of a semi-rigid gel, possessing a considerable elasticity, though the two regions may very probably grade into one another imperceptibly.

Finally, the experiments of Hyman (**13**) reveal in each pseudopodium of *Amoeba* a gradient in susceptibility to potassium cyanide, the susceptibility being greatest at the distal end and decreasing proximally. This susceptibility gradient is regarded as being a metabolic gradient which arises before the pseudopodium appears, 'and hence the metabolic change which produces increased susceptibility is the primary cause of pseudopodium formation.' Liquefaction or solation is regarded as the cause of the extension of a pseudopodium, and coagulation or gelation as the cause of its retraction: the liquefaction is believed to be brought about by the metabolic change just re-

ferred to. This theory that amoeboid movemnt is due to alterations of the colloidal state is only in the nature of confirmation and extension of the view advanced more than forty years ago by Montgomery (17, 18) that protoplasmic movement of amoeboid organisms consists in 'an alternate expansion and contraction of organic substance': Montgomery even anticipated Hyman in expressing the idea that the liquefaction which occasions pseudopodium advancement is itself due to metabolic changes, while he anticipated Rhumbler (19) in the idea of a non-homogeneity of the primitive protoplasmic mass which permits various functions to be carried on in different regions at the same time.

This somewhat lengthy excursus (which is yet only the briefest possible summary of a voluminous literature) has been introduced here only to bring before botanists, to whom the field may be unfamiliar, facts which it is believed may be directly applied in the case of the chlamydomonads we are considering. The form development of *Lobomonas*, *Brachiomonas*, and *Pteromonas* must be essentially amoeboid for a brief period during the organization of the daughter cells, and we are justified in assuming that their lobes and excrescences are the expression of the same non-homogeneous organization of the protoplast as is characteristic of *Amoeba*.

For this view, furthermore, we may draw an additional parallel from the results of microdissection. In the developing oogonium of *Fucus*, Seifriz reports (21) that the viscosity of the protoplasm changes from liquid consistency in the young uninucleate stage to slightly viscous consistency when the division into eight eggs is just complete, and to decidedly viscous consistency (just under the viscosity of glycerine) in the mature normally discharged egg: that is, in Seifriz's scale of ten grades of viscosity—the first attempt on the part of microdissectionists at standardization in this matter—the variation is from grade 3 to grade 6. Yet further, from the behavior of disintegrating eggs of *Fucus*, Seifriz (20) finds that the process may be localized in such a manner as to indicate 'a gross structure of the egg plasm, *i. e.*, the protoplasm is composed of many centers of activity in which different chemical reactions take place.' I have recently found a condition almost precisely similar in the case of a newly discovered polyblepharid genus which it is hoped may soon be published. The cells of this species, though surrounded only by an exceedingly delicate protoplasmic membrane, are never-

theless able to maintain for extended periods an elaborately eight-ridged or winged prismatic form, and in disintegration often break only at one or two points, thus permitting the greater body of the protoplasm to remain practically intact, while only small streams ooze out. From these observations we are justified in concluding that such cells as those of *Brachiomonas* and *Lobomonas*, could we apply methods of microdissection, would be found to have protoplasm of a comparatively fluid consistency during division, but that local increase in viscosity gradually permits the fixation of the characteristic lobed form of the cell. When it is recalled that in these two genera the pyrenoids regularly disappear in preparation for cell division, and are reorganized with the maturing of the daughter cells, it will readily be seen that in this reorganization, combined with the ordinary processes involved in division of cells inheriting differentiation of polarity in at least three axes or planes, there is abundant room for the play of such metabolic changes as might well account for considerable differences in viscosity in different parts of the developing daughter protoplasts. It is this non-homogeneity of structure, involving very likely chemical as well as physical differences, which may be regarded as the dominant factor in the determination of form in such organisms. From this standpoint, the problem as to how this characteristic form may be transmitted in heredity does not seem so insoluble as it does on the assumption of form determining unit factors in a germ plasm.

One further point may be emphasized. It is stated by Thompson (22) that when 'owing to some heterogeneity of the substance' the operation of uniform surface tension forces is modified so as to result in the production of the ellipsoid cell characteristic of yeast, for example, 'this or any other asymmetrical form, once acquired, may be retained by virtue of the solidification and consequent rigidity of the membranous wall of the cell.' In the case of the organisms with which we are here concerned at least, I am confident, the development of the cell wall is not a necessary condition of the maintenance of specific form; for the new polyblepharid mentioned above, and others of the same group, as well as the gametes of *Brachiomonas*, are able to preserve essentially the same form for long periods, in spite of the fact that they are clothed only with a protoplasmic membrane of such excessive thinness that it is practically undemonstrable. It is then, owing to relative viscosity in their

protoplasmic substance that these motile organisms are able to attain and maintain their specific form.

In both *Brachiomonas* and *Lobomonas* we have noted that not infrequently mature cells exhibit a more or less rounded form of the protoplast inside of the cell wall, while the latter maintains the typical lobed form as fixed in the formative period. Such conditions are not improbably produced by shrinkage due to loss of a certan amount of water from the protoplast, accompanied by a tendency to decrease in viscosity of the outer layer, in which case, surface tension would tend to bring about a more rounded form. In other words, the maturing protoplast might be said to show a tendency to revert to what might be considered the ancestral form in preparation for reproduction.

It is a pleasure to acknowledge my debt to Professor R. A. Harper for numerous stimulating discussions of problems connected with morphogensis, and for reading this paper in manuscript.

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Explanation of plates 5 and 6

Figures drawn with camera lucida from living material kept in hanging drops (VanTieghem cells of standard height of 5 mm.): Leitz compens. oc. 12 was used in combination with oil immers. obj. 1-12 inch, or Spencer 2 mm. The drawings have been reduced one half in reproduction, making the present magnification approximately 1150 diameters for FIGS. 1–21 and 41; and 1375 diameters for FIGS. 22–40.

PLATE 5

LOBOMONAS PENTAGONIA Hazen

FIGS. 1–5. Typical vegetative cells or zoospores: in FIGS. 1–3 the stigma lies on the under side of the cell.

FIG. 5. Anterior polar view: four anterior lobes emtpy, chromatophore filling four posterior lobes.

FIG. 6. Protoplast rotating clockwise in preparation for division; 7 P. M.

FIG. 7. The same cell at 7:05 P. M; beginning of cleavage.

FIG. 8. Division into two zoospores completed at 6:30 P. M.

FIG. 9. Another individual: pyrenoid and cilia beginning to appear in daughter cells; nucleus in most advanced lobe: 10:30 P. M.

FIG. 10. Pentagonal form attained by daughter cells.

FIG. 11. Four daughter cells in one plane.

FIG. 12. Two daughter cells with axes perpendicular to those of the other pair.

FIG. 13. An unusually simple form: cilia contracted into a ball.

FIG. 14. Cell in posterior polar view.

FIGS. 15–20. Stages in conjugation of a pair of slightly unequal gametes: FIG. 15 at 1:45 P. M.; FIG. 16 at 2:15; FIG. 17 at 2:16; FIG. 18 at 2:25; FIG. 19 at 2:40; Fig. 20 at 2:45.

FIG. 21. Zygote formed by conjugation of equal walled gametes.

PLATE 6

LOBOMONAS ROSTRATA Hazen

FIGS. 22–27. Typical young vegetative cells.

FIGS. 28, 29. Mature cells of less common form, but with well developed wall, FIG. 29 showing edge view of beak.

FIG. 30. Anterior polar view.

FIGS. 31, 32. Cells showing persistence of form some time after loss of motility.

FIG. 33. Relatively large mature cell, pyrenoid and stigma underneath.

FIG. 34. The same cell 24 hours later: four daughter cells completely organized except for cilia, 11 P. M.

FIG. 35. One of the four daughter cells, one day later, not very well formed, probably because of unfavorable conditions.

FIG. 36. Beginning of cleavage, after clockwise rotation of protoplast; 9:30 P. M.

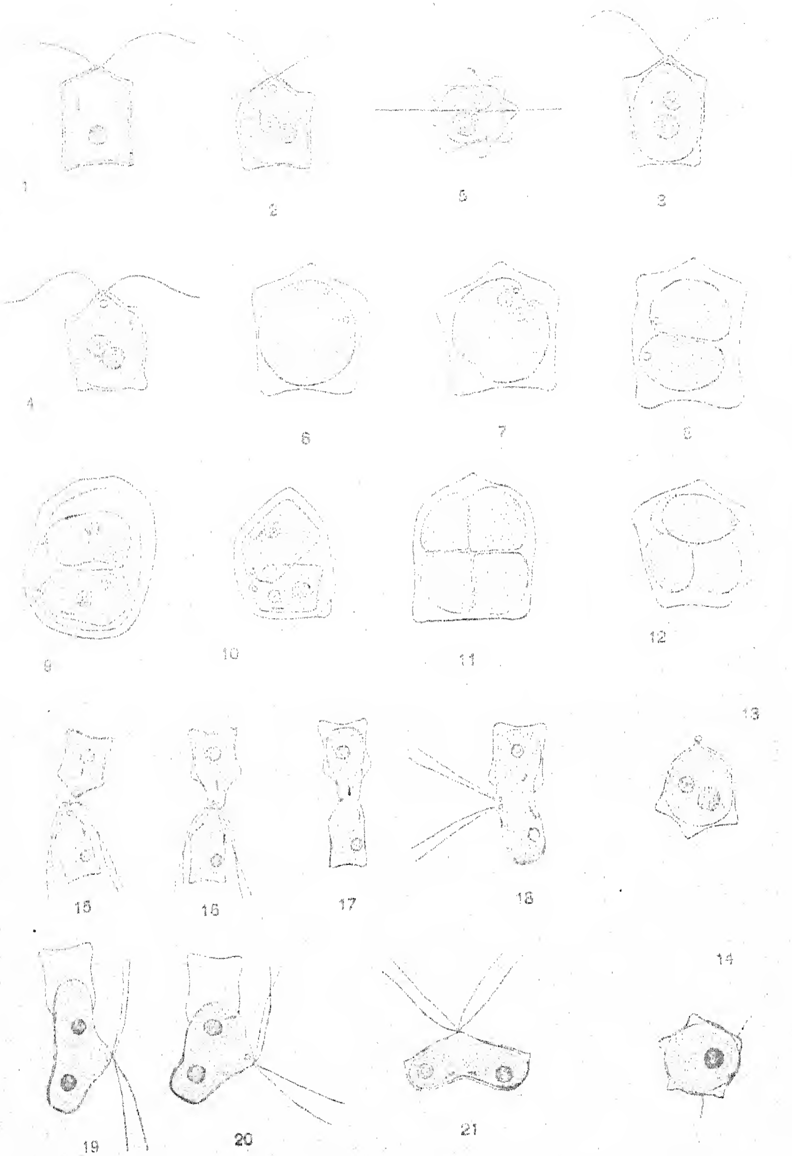
FIG. 37. Similar division, after rotation of protoplast in vertical plane; 10:30 P. M.

FIG. 38. Second cleavage just completed; 10:30 P. M.

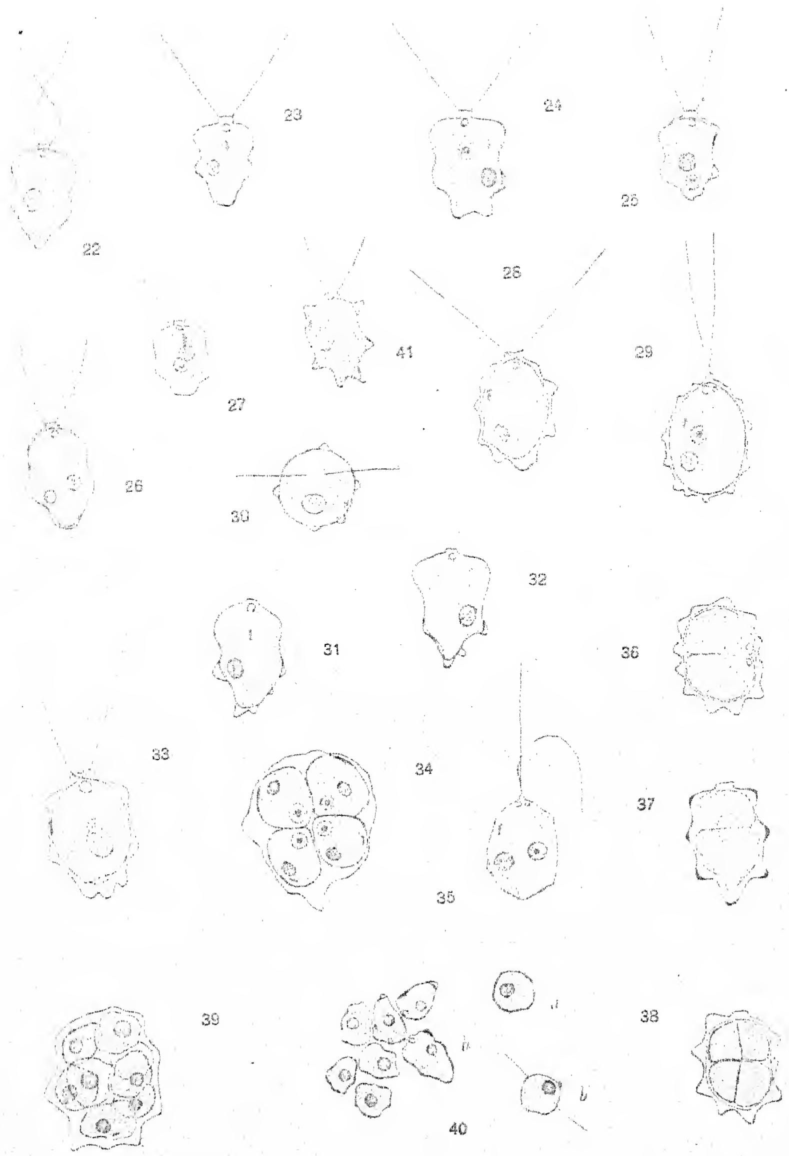
FIG. 39. Eight daughter cells (perhaps gametes) 6 P. M.

FIG. 40. The same at 9:30 P. M.: daughter cells held by gelatinized wall of mother cell: cell *a* moved out sluggishly at 8:30; at 10 P. M. cell *b* backed out and presently rested on end, cilia downward as at b^1.

FIG. 41. Mature cell from Shelburne, Vermont, August 3, 1921. All other figures from New Jersey material, in 1919.



LOBOMONAS PENTAGONIA Hazen



LOBOMONAS ROSTRATA Hazen

The development of the flower and embryogeny of Martynia louisiana

Flora Anderson.

(WITH PLATES 7 AND 8 AND TWENTY-FIVE TEXT FIGURES)

Introduction

The most common and widely distributed representative of the Martyniaceae in temperate North America is *Martynia louisiana* Mill. Although the literature on the family is chiefly taxonomic, the descriptions are meagre and confusing. All the species have, at some time, been placed in the genus *Martynia*. The ten or more known species comprise three genera, native to the warmer parts of the western hemisphere.

Efforts were made to secure seeds and to grow plants of the different species for comparison, in order, if possible, to work out the taxonomy of the family. Seeds were obtained from seed-houses both in the United States and in England and also from the Bureau of Plant Industry, the University of Texas and the Mississippi Agricultural College.

From seeds secured through the Bureau of Plant Industry, quite a number of plants of *Martynia louisiana* were grown—all the plants producing viable seeds—and one specimen of *Martynia lutea* Lindl. which, although maturing seemingly normal fruit from selfed flowers, produced no viable seeds. Reciprocal crosses of *Martynia lutea* and *Martynia louisiana*, and of *Martynia lutea* and *Martynia fragrans* Lindl. failed.

From seeds furnished by seed-houses, the University of Texas and the Mississippi Agricultural College, quite a number of plants of *Martynia louisiana* and *Martynia fragrans* were grown in Montgomery County, Indiana, during the summers 1915–1919. The two species mentioned above cross very readily, producing in all cases viable seeds. These plants, grown in the open in rich soil and under practically the same conditions, showed very few differences except in the color of the corolla, which is more or less a variable character. The similarity of the plants seems to indicate that they belong to the same species, but more cultures must be studied before this point can be definitely determined.

In as much as no morphological work seemed to have been done on this family, a study of *Martynia louisiana* and *Martynia fragrans* was undertaken, the results of which are given in the following pages. While the study was based mainly on *Martynia louisiana* no structural differences between the two species were observed.

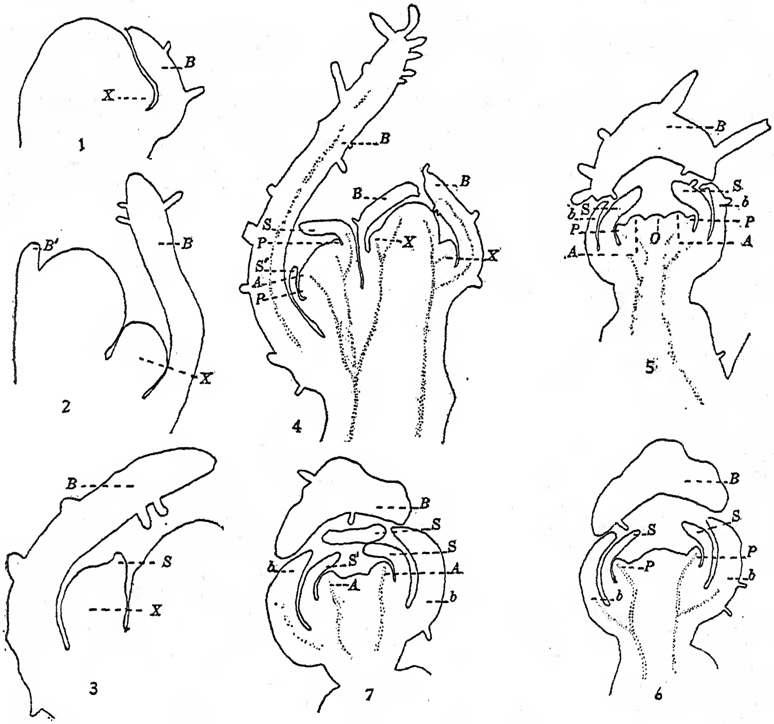
MATERIAL AND METHODS

The material used for this study was collected from plants of *Martynia louisiana* and *Martynia fragrans* grown in the field, in Montgomery County, Indiana. Collections were usually made during the month of August, when the plants were most vigorous. The apices of racemes, small flowers and stamens, pistils and young fruits in various stages of development were killed and fixed in a 1 per cent chromo-acetic acid or in chrom-osmic-acetic acid one to two hours and then in chromo-acetic acid twenty-four to thirty-six hours, washed, dehydrated, and embedded through chloroform. To determine the time necessary for the pollen tube to reach the egg, pollination was controlled, and, beginning at one hour after the application of the pollen, collections were made at intervals of one hour for fourteen consecutive hours. These collections were of whole pistils which were killed and fixed in chrom-osmic-acetic acid one to two hours and then in chromo-acetic acid thirty-six hours. Beginning thirty hours after pollination, collections of pistils and young fruits were made at intervals of six hours for two hundred and four hours. Sections were cut 4–10 μ, most of them 5 μ thick; those of whole pistils were longitudinal and 4–5 μ in thickness. Both modified triple and Heidenhain's iron-alum-haematoxylin were used for staining, the former being more satisfactory.

THE DEVELOPMENT OF THE FLOWER

As in most inflorescences, the flower of *Martynia louisiana* arises as a lateral branch (FIG. 1, X) in the axil of a bract (FIG. 1, B). The first bract arises as a lateral papilla near the apex of the main axis of the raceme (FIG. 2, B′). This bract grows rapidly and about the time its tip reaches the apex of the raceme, a rather broad protuberance appears in the axil (FIG. 1, X). With further growth of the axis of the raceme other bracts appear, and in the axils of these the primordia of other flowers develop (FIG. 4, X). As the rudiment of

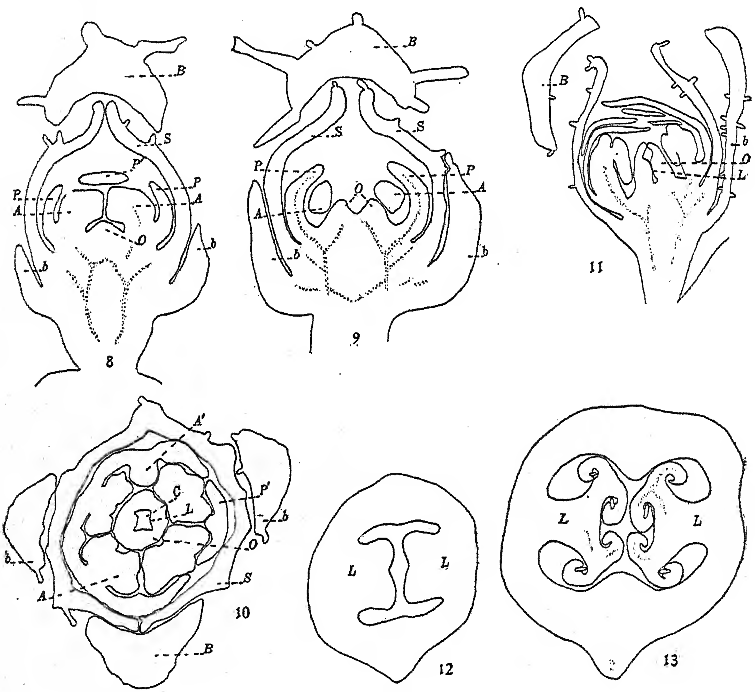
the flower grows it becomes broader and somewhat oblique at the apex (FIGS. 2 and 3, X). On the adaxial side of the primordium of the flower there appears a protuberance or ridge, the upper lobe of the calyx, extending about one third the distance around it (FIG. 3, S). Very soon the other lobes of the calyx appear as small protuberances similar to the adaxial lobe. The individual lobes appear as separate protuberances, but later grow up as a tube except on the abaxial side of



FIGS. 1–7. Development of the flower. FIGS. 1–3, × 45; FIGS. 3–7, × 30. B, bract; X, flower primordium; S, S', calyx lobe; P, corolla lobe; A, stamen; O, pistil; b, bracteole.

the flower. At this point, the two lower lobes of the calyx are united only at the base and in the mature flower overlap. The adaxial lobe of the calyx is the largest, and in the bud covers the other lobes (FIGS. 4 and 7, S). The calyx lobe, shown at S′ in FIG. 4, is the edge of one of the lateral lobes and appears smaller than it really is. Just within the calyx lobes are seen small

protuberances (FIG. 4, P), the primordia of the corolla lobes, which are alternate with those of the calyx. Arising simultaneously with the corolla lobes (FIG. 5, P) and alternate with them are the epipetalous stamens (FIG. 5, A). FIGS. 6 and 7 are other sections of the flower shown in FIG. 5. FIG. 6 is a median section through the primordia of two lobes (P) of the corolla, while FIG. 7 is a median section through the primordia of two stamens (A). A comparsion of these two figures will give the relative size of the parts at this stage. There are primordia



FIGS. 8–13. Development of the flower (*con.*), × 30. B, bract; b, bracteole; S, calyx lobe; P, P¹, corolla lobe; A, A¹, stamen; O, pistil; L, placenta; C, ovarian cavity.

of five stamens, but very early the one between the posterior pair becomes aborted (FIGS. 10 and 14, A′). The pistil is the last cycle to appear, and in FIG. 5 is seen as a broad protuberance (O).

In FIGS. 5–9, at B, are seen cross sections of the bract which curves over the flower. These figures are of the flower as viewed from the adaxial side. And in the same figures at b, are seen sections of the two bracteoles. The two bracteoles arise as

protuberances similar to those of the lobes of the calyx, but earlier than the calyx lobes. The bracteoles develop inferior to the calyx, opposite each other and at right angles to the bract (FIG. 10, b, B). Since FIG. 9 is a median section through the flower, only the edge of each bracteole is shown. At this stage, they are large enough to cover the young flower.

FIGS. 8 and 9 show the further development of the parts of the flower. The calyx (S) is large enough to cover the other floral parts. An almost median section of two lateral lobes (P) of the corolla is shown in FIG. 9, while a cross section of the tip of the lower lobe is shown at P^1 in FIG. 8. The lower lobe of of the corolla is the largest and in the bud is covered by the others. The manner in which the corolla lobes overlap is shown in FIG. 11. A median section through two of the stamens (FIG. 8, A) of the same flower shows the further development of the stamens seen at A, FIG. 7. As in most cases, the development of the anther precedes that of the filament (FIG. 8, A). However, at this time the tissue of the anther is undifferentiated. At the time the pollen mother-cells are formed the filament is still shorter than the anther. The filaments remain short (FIG. 14) until almost the time of anthesis, when they elongate rapidly, bringing the anthers into the throat of the corolla, just below the lips of the stigma (FIG 16). The stamens are didynamous, the posterior pair being the longer. Just before anthesis, the lobes of the anther diverge, forming a straight line transverse to the filament. At the same time, the filaments of the corresponding pairs of stamens converge in such a way as to bring the diverging anthers into contact (FIG. 16) along the line of their linear dehiscence. At time of shedding, the rather large pollen grains are characterized by an exine that is thickened in the form of hexagonal areas.

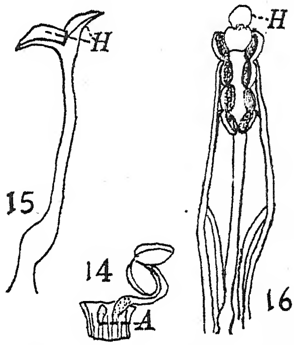


FIG. 14. Immature stamen. A, aborted stamen.

FIG. 15. Mature pistil, slightly enlarged. H, stigma lobes.

FIG. 16. Mature pistil and stamens in position. H, stigma lobes.

As was stated previously, the pistil appears as a rather broad protuberance (FIG. 5, O), but soon a depression is formed in the center (FIG. 9, O). The primordium of the pistil continues

to grow up as a ring enclosing a central ovarian cavity as is seen in cross section (FIG. 10, C). At a very early stage in the growth of the pistil, two parietal placentae appear. These are seen as outgrowths from the walls of the cavity (FIGS. 10 and 11, L). These outgrowths extend toward the center of the cavity and soon each forms two lobes (FIG. 12, L) which develop into the two lamellae of each placenta, resembling in cross section the letter T (FIG. 13, L). The placentae grow together at the base, thus forming a short columella. A cross section through the base of the ovary would appear as two-celled, but no ovules are developed from this region of the placentae. The upper part of the pistil is tubular and more narrow, forming a long, slender, hollow style which terminates in an unequally two-lipped stigma (FIG. 15, H).

DEVELOPMENT OF MEGASPORE AND EMBRYO-SAC

The young ovule first appears as a small, nipple-like protuberance upon the placenta. Very early in its development, a hypodermal cell near the tip becomes differentiated and may be distinguished from the surrounding cells by its large nucleus and dense cytoplasm (PLATE 7, FIG. 17). This cell, the megaspore mother-cell, grows rapidly, keeping pace with the lengthening nucellus. At this stage, the nucellus consists of merely the enlarged megaspore mother-cell, covered by the epidermis (FIG. 18). At the base of the nucellus the single integument appears as a fold, at first more pronounced on the side next to the cavity of the ovary (FIG. 18, I). By the more rapid growth of this side the ovule soon becomes sharply curved, so that the long axis of the nucellus is now parallel with that of the funiculus. At this stage, the integument extends around the nucellus, which has become more elongated (FIG. 19). With further growth the integument soon equals and finally exceeds the nucellus (FIGS. 20 and 21). The megaspore mother-cell has also grown rapidly and when fully developed is still enclosed by only a single layer of nucellus (FIG. 21). The nucleus, which has increased in size preparatory to the first division and which has had a position near the center of the cell (FIG. 20), comes to lie nearer the chalazal end, where it undergoes the first or heterotypic division (FIG. 21). All the spindles of this stage found were rather small as compared with the size of the cell. Whether cell formation follows this first nuclear division was not ascertained, but the

typical axial row of four megaspores is finally formed (FIG. 22), and, as is usually the case, the innermost megaspore, the one next the chalazal end, persists to form the embryo-sac (FIGS. 22 and 23). The upper three potential megaspores are soon destroyed by the rapid growth of the functional one (FIG. 23.)

By the time the tetrad is formed, the nucellus has reached its maximum growth, and the cells of the integument adjacent to the nucellus have become dense in cytoplasm and now function as a nutritive jacket (FIG. 22). In the meantime the integument has grown and exceeds considerably the length of the nucellus (FIG. 23).

The functional megaspore does not increase much in size before the first nuclear division but, after this first division, it elongates rapidly and occupies a space almost the length of the nucellus (FIGS. 23 and 24). As the megaspore elongates the two nuclei keep their relative positions—one in each end of the cell. Most of the cytoplasm of the cell is in the ends, thus leaving a large vacuole in the center. A few strands of cytoplasm penetrate the vacuole and form a connection between the masses at each end of the cell. The rapid growth of this cell has consumed the three upper potential megaspores and the nucellus around the center of the spore (FIG. 24). Before the second nuclear division of the megaspore takes place, the upper three megaspores have practically disappeared and the functional one now extends nearly the length of the nucellus, which is rapidly being used as food (FIG. 25). At this time the central vacuole is not so pronounced—at least in some cases. The spindles of the second nuclear division may be seen—one in each end of the cell. With the exception of a few cells at the chalazal end, the nucellus is consumed by the growing megaspore, which comes to occupy the space left by the disorganizing tissue. There is no evidence of a nucellar cap being formed as Merrell reported for *Silphium* (3) and other plants that have a similar development. The nuclei now undergo another division which results in eight nuclei—four in each end of the cell. Next follows the formation of the three cells of the egg-apparatus and the three antipodals. One nucleus from each end of the embryo-sac, the polar nuclei, remains free in the cytoplasm. At this stage, the embryo-sac is considerably elongated, being about seven times as long as wide. The micropylar end, containing the egg-apparatus, is enlarged to about one and a half times the diameter of the other part of the sac. This enlarged portion comprises nearly one

third the length of the embryo-sac. The egg-apparatus consists of the large pear-shaped egg-cell, which extends far down into the sac cavity, and the two large synergids (PLATE 8, FIG. 26, G and Sn). The lower part of the egg in which the nucleus lies is well filled with cytoplasm, but the upper part is vacuolate. The synergids, one on either side of the egg, extend down about two thirds the length of the egg-cell. Each synergid has a diameter nearly equaling that of the egg and a centrally located nucleus, which is a little smaller than the egg nucleus. As is frequently found in other angiosperms, a fairly large vacuole lies below the nucleus in the synergid (FIG. 26, Sn).

In the chalazal end of the embryo-sac are the three, rather long, slender, well-developed antipodals (FIG. 26, N). In most instances, the nuclei of the antipodals are fairly large and the cytoplasm has the character of that of the body of the embryo-sac.

After the formation of the cells at either end of the embryo-sac the polar nuclei move to the center and lie side by side for some time (FIG. 26, Pn), but before the pollen tube reaches the embryo-sac, the two polar nuclei fuse (FIG. 27). Sections were made of ovaries from flowers in which pollination had not occurred and it was found that the polar nuclei had fused (FIG. 28). So the fusion of the polar nuclei is in no way due to a stimulus from the pollen tube. The fusion nucleus does not approach the egg-apparataus, as Kanda reported for *Verbena* (2), but remains in the center of the embryo-sac. Each polar nucleus has a very prominent nucleolus and after fusion the two nucleoli are very noticeable for some time (FIG. 27), but later only one large nucleolus is usually seen (FIG. 28).

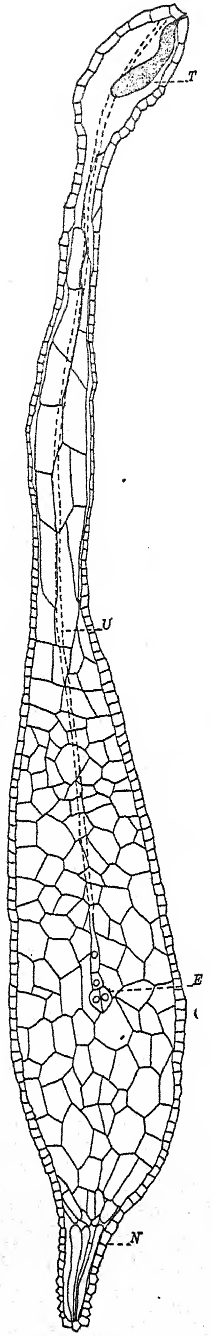
POLLINATION

The polar nuclei seem to unite about the time of anthesis, for conditions like those represented in FIG. 26 are observed in ovaries fixed just before the expansion of the corolla lobes, while the fusion nucleus is seen in flowers that have been open one or two hours. Most of the flowers open early in the morning, and shortly after daylight the bees, which are the chief pollinizing agents, are busy gathering nectar from the lower portion of the corolla tube.

The two lobes of the sensitive stigma stand open just above the open anthers (FIG. 16), in the upper portion of the throat of the corolla, and the bee, entering the corolla tube, brushes the stigma, thus depositing the pollen that may be present on the upper part of its body and securing a new supply from the open anthers just below as it walks down the tube. The stigma is very sensitive when the flower first expands and the slightest touch will cause the lobes to close. If pollen be present they usually remain closed, but, in the absence of pollen, they re-open in from five to ten minutes. If pollen is witheld the stigma lobes may be made to close and open many times, but after one to three days the stigmas tend to lose their sensitiveness. However, this sensitiveness is not an index to the receptiveness of the stigmatic surface, for flowers hand pollinated after the stigma ceased to be sensitive and even after the corolla dropped, produced viable seeds. Viable seeds were also secured from flowers hand pollinated in the bud before the stigma lobes normally opened. This was accomplished by gently forcing pollen between the closed lobes by means of a needle. In most flowers thus treated the stigma lobes never opened. At this time the anthers are still closed, but pollen from these as well as from open anthers was shown to be effective.

FERTILIZATION

Usually the pollen grains germinate immediately on the stigmatic surface, as was readily seen in material fixed one hour after the pollen was applied. At this time, many of the tubes were well into the tissue of the style. The growth of the pollen tube through the tissue, usually two or three cells from the stylar canal, is very rapid, for fertilization frequently occurs within six hours after pollination. The pollen tube is filled with plastids and granules that take such a dense stain that it is impossible to demonstrate the presence of the sperm nuclei, but, since the long, slender crescentic generative cell in the mature pollen grain shows only one nucleus, it is thought that the formation of the two sperms takes place in the tube. The pollen tube, as it grows nearly straight down through the style to the placenta, is comparatively broad and seems to retain its densely staining quality throughout the greater part of its length.



On reaching the ovule, the pollen tube grows through the micropyle and enters the embryo-sac, sometimes a little to one side, crushing one or both the synergids. The tip of the pollen tube usually covers the egg-cell, thus obscuring the nucleus of the latter (FIG. 32). In some instances it seems that the tube enters the egg-cell at the upper end and transverses the entire length of it (FIG. 31). In all cases observed, there was evidence that the tube had discharged the sperm nuclei in such a way that one of them came in direct contact with the egg nucleus (FIG. 30). Only the sperms and a little of the contents from the tip leave the pollen tube (FIGS. 30 and 31). The fate of the second sperm nucleus was not ascertained, but it seems evident that it plays no part in the formation of the endosperm. The second sperm nucleus may not leave the tube, but this point can not be demonstrated until some method of fixing and staining can be found that will reveal the presence of the nuclei among the granules in the cytoplasm. The pollen tube in the micropyle and in the upper part of the embryo-sac retains its form and densely staining quality long after the embryo-sac is filled with endosperm (FIG. 35).

The actual union of sperm and egg nucleus is similar to that in other angiosperms. The instances of fertilization observed were similar to that of *Lilium Martagon*, figured by Mottier (4). For *Verbena*, Kanda (2) figures the sperm nucleus in contact with the egg-cell and speaks of it as fertilization. In all the fertilization stages observed in *Martynia*,

FIG. 35. Embryo-sac filled with endosperm, × 140. T, pollen tube; N, antipodali; E, embryo; U, suspensor.

the sperm has been in direct contact withthe egg nucleus. This would seem to indicate that the pollen tube carries the sperm into the egg-cell.

THE ENDOSPERM

The primary endosperm nucleus, resulting from the union of the two polar nuclei, occupies a position near the center of the embryo-sac. Usually before the pollen tube enters the sac this endosperm nucleus divides and a transverse wall is formed between the two resulting nuclei, thus dividing the embry-sac into two chambers (FIG. 29). At this time, the cytoplasm in the embryo-sac has a frothy appearance due to the many small vacuoles present. This frothy character seems to appear after the fusion of the polar nuclei (FIG. 28). Very conspicuous, densely staining plastid primordia and granules are present in the cytoplasm. The synergids seem to have increased in length and to have become more vacuolate (FIG. 29). The egg-cell remains apparently unchanged. The antipodals are more elongated and sometimes contain a granular, densely staining cytoplasm (FIG. 29). After the wall dividing the embryo-sac into two chambers is formed, the nuclei move to a nearly central position in their respective cells. And, as one would infer, the endosperm cell at the micropylar end of the sac grows more rapidly than the one at the chalazal end (FIG. 31). The pollen tube usually reaches the embryo-sac when the endosperm is in a two-celled stage. In FIG. 31, it may be seen that fertilization has taken place. The outline of the tip of the pollen tube is shown by a dotted line in the lower part of the egg-cell, and the shading represents the relative density of the contents in different parts of the tube. Only the tip seems to have discharged its contents. A remnant of one synergid still shows. The synergids, if not crushed out by the entrance of the pollen tube, are soon absorbed. The endosperm cell in the micropylar end of the sac is very large and contains a large nucleus with irregular outline and a prominent nucleolus. Many plastids are still seen in the frothy cytoplasm of both endosperm cells, and some are present in the antipodals, which continue to grow, especially in length (FIG. 31). The increase in size of the antipodals is better illustrated in FIG. 32. Their cytoplasm is somewhat vacuolate at this stage and the large nuclei contain very prominent nucleoli. Usually the first division of the endosperm cell is transverse

and the second longitudinal, the one in the micropylar end dividing before the one in the chalazal end; but, in FIG. 32, it appears as if the first division had been longitudinal and the second transverse. The cytoplasm in the large cells around the fertilized egg contains many large as well as small vacuoles, while that of the lower cells contains only small ones. Very few plastids are present at this stage. They are seldom noticeable in later stages of endosperm development. FIG. 32 shows also the old densely staining pollen tube in the micropyle and upper end, of the embryo-sac, its tip covering the fertilized egg. By focusing down on the tip of the tube, the nucleus of the fertilized egg is seen and is represented in the drawing by a dotted line (FIG. 32). In the meantime, the whole embryo-sac has been enlarging at the expense of the integument which also has grown. The enlargement is more pronounced at first in the micropylar end where the fertilized egg is elongating. The layer of cells of the integument adjacent to the embryo-sac is always dense and rich in cytoplasm and functions as a nutritive jacket to the growing endosperm. FIG. 33 shows the further development of the endosperm, and the elongation of the fertilized egg. The old pollen tube is still very prominent in the micropyle and upper end of the sac, obscuring the upper portion of the fertilized egg-cell. The cytoplasm in the large endosperm cells of the micropylar end is very vacuolate, due probably to the rapid growth of the cells and to the loss of food to the developing embryo. Only a few endosperm cells develop in this end of the sac, for very soon a long suspensor is formed which brings the embryo into the chalazal end. The endosperm cells in the middle of the sac are smaller and richer in cytoplasm than the upper ones. The antipodals have nearly reached their maximum growth. They seem to function as elaborators of food and persist long after the embryo-sac is well filled with endosperm (FIG. 35). In several cases, four antipodals, all well developed, were found (FIG. 33). The extra one had probably been formed by the

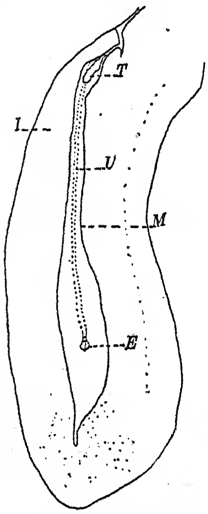


FIG. 36. Outline of ovule, $\times$ 44. I, integument; M, embryo-sac E, embryo; U, suspensor; T, old pollen tube.

division of one of the three normal ones. FIG. 34, a cross section of the chalazal end of an embryo-sac in the same stage as the above, shows the arrangement of the four antipodals. At this stage, the nuclei of the antipodals appear as densely staining homogeneous masses.

As the embryo with its very long suspensor grows through the center of the elongating embryo-sac, large endosperm cells rich in cytoplasm are formed, but when it reaches the lower part of the sac where the first division of the embryo takes place, the endosperm growth practically ceases in the middle and upper part of the sac. The cells of this part of the sac are rather large and similar in shape to those first formed, while those in the lower part are smaller and not so rich in cytoplasm (FIG. 35). It is also seen from FIG. 35 that the embryo-sac has enlarged considerably, especially the lower part which contains the developing embryo. The nutritive jacket is still very active in the elaboration of food for the growing endosperm. FIG. 36 shows in outline the relative size of the embryo, endosperm and integument at the time the embryo is in the two-cell stage as seen in FIG. 35.

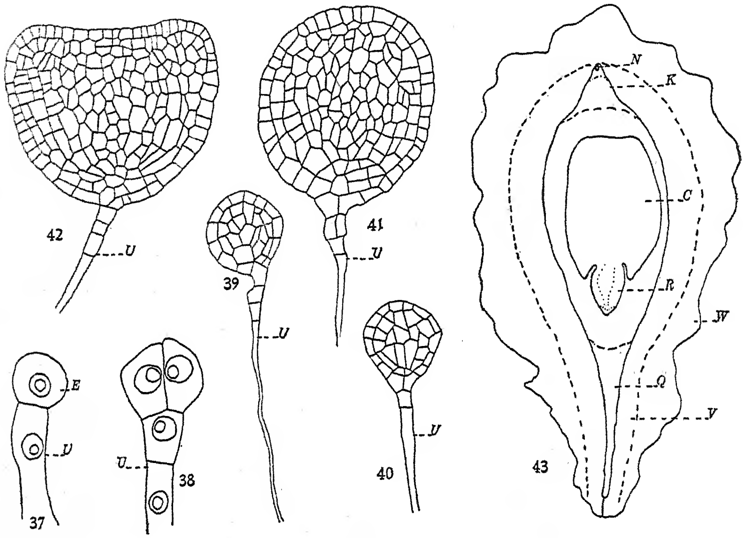
THE EMBRYO

After fertilization, the egg with its nucleus occupying a nearly central position in the lower part of the cell grows rapidly in length (FIG. 33). Its manner of growth down through the endosperm is similar to that of a pollen tube, for it becomes a long narrow cell with the nucleus retaining a position near the growing tip. No division seems to take place until the distal end has transversed nearly two thirds the length of the embryo-sac. The lower portion of the cell is rather dense in cytoplasm and stains deeply, but the upper portion has very little and stains so faintly that the course of its growth is hard to trace.

After the distal end has reached the lower portion of the embryo-sac, a transverse division occurs, which forms a very long, slender suspensor cell and a short, rounded distal one, the embryonal cell (FIG. 37). In most instances the cytoplasm of the embyonal cell contains many plastids and other densely staining granules, while that of the suspensor is very poor in plastids. After the first division two others occur almost simultaneously. The suspensor cell divides, forming a short cell next the embryonal cell, which has enlarged preparatory to division, and, at the

same time, the enlarged embryonal cell divides longitudinally forming a two-celled embryo (FIGS. 38 and 35). The second division of the embryo is usually transverse and the third longitudinal, thus forming the octant stage The further growth of the embryo is illustrated in FIGS. 39–43 and is so like the well known development of *Capsella* that details are unnecessary.

The very long suspensor, shown in Fig. 35 in dotted lines, is almost indentical with that of *Trapella sinensis* Oliv. as figured by Oliver (5, *pl.* 7, *f.* 36). The suspensor of *Myoporum*



FIGS. 37–43. Development of the embryo. FIGS. 37–38, × 500; FIGS. 39–42, × 175; FIG. 43, × 6. E, embryo; U, suspensor; C, cotyledon; R, radicle; K, chalazal end of embryo-sac; Q, micropylar end of embryo-sac; N, remains of antipodals; V, soft, inner portion of seed coat; W, hard, warty portion of seed coat.

serratum as figured by Billings (1, *f.* 51) is also similar in structure but does not push the embryo as far down into the embryo-sac as that of *Martynia*, although the shape of the embryo-sac and the development of the endosperm are much the same in both species. Usually a second and sometimes a third division occurs in the suspensor, resulting in two or three short cells next the embryo, the innermost of which seems to contribute to its formation.

FIG. 43 shows a section of a young seed containing a nearly mature embryo. The radicle (R) is short and thick while the

cotyledons (C) are very large and fleshy. This figure shows also a little endosperm which, in the mature seed, comprises a thin, transparent covering for the embryo. The embryo has developed in such a way that it practically fills the lower part of the sac, while the upper and middle portions (Q) form in the mature seed a little brown tube on the micropylar end of the remaining endosperm. There is also a small brown knob at the chalazal end (K) marking that part of the embryo-sac formerly occupied by the large antipodals, the remains of which appear at N. The broken line in this figure represents the demarcation in the tissue forming the seed coat. That region of tissue next the endosperm (V) matures into the soft inner portion of the seed coat, while the walls of the cells forming the outer portion (W) become thick and lignified, thus maturing into a hard warty exterior which becomes very dark brown or black in color.

SUMMARY

The flowers develop in the axils of protective bracts. The cycles of the flower appear in the following order: calyx, corolla and epipetalous stamens, and pistil.

Of the four potential megaspores formed, only one is functional.

The embryo-sac is long and narrow, with the micropylar end considerably enlarged. The large egg-cell extends far down into the sac cavity, with the two synergids on either side. The three antipodals are long, slender cells that increase in size and persist as elaborators of food.

The polar nuclei move to a position near the center of the sac where they unite before the pollen tube reaches the ovule.

Fertilization usually occurs within six to eight hours after pollination.

The rather large pollen tube stains densely throughout the greater part of its length and persists in the micropyle and upper end of the embryo-sac long after the endosperm is formed.

The first division of the endosperm cell, which is usually transverse, occurs before fertilization. At first, a few cells are formed in the upper and middle portions of the embryo-sac, but the bulk of the endosperm is in the lower part of the sac, where the embryo develops.

The suspensor is very long and narrow and pushes the embryo

into the lower portion of the embryo-sac, where the first division takes place. The development of the embryo proper is like that of *Capsella*.

I take opportunity here to express my obligations to Professor H. W. Anderson for the use of the Wabash College Botanical Laboratory during the summers of 1915 and 1916 and to Professor D. M. Mottier for valuable assistance and criticism in connection with this study.

INDIANA UNIVERSITY

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Explanation of plates 7 and 8

PLATE 7

All figures, × 400

FIG. 17. Vertical section through the nucellus; megaspore mother-cell shaded.

FIG. 18. Elongated nucellus with megaspore mother-cell; beginning of integument, I.

FIG. 19. Vertical section of young ovule turned on its axis; the integument reaching half the length of the nucellus.

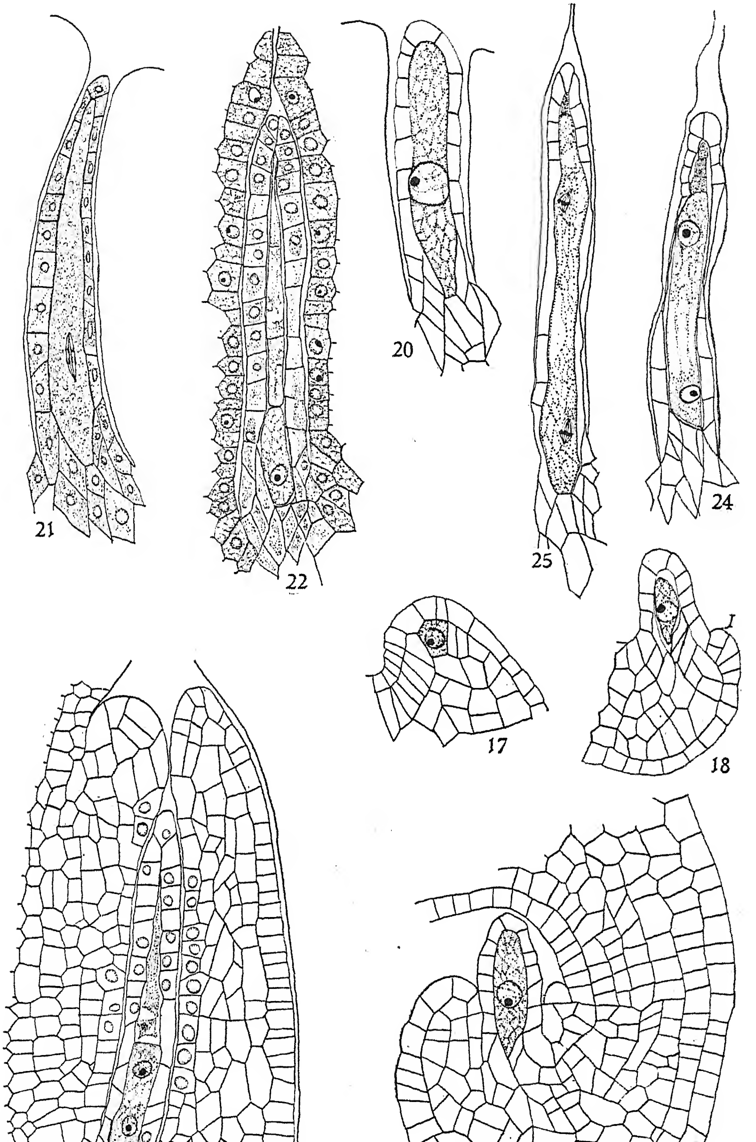
FIG. 20. Nearly mature megaspore mother-cell enclosed in a single layer of nucellus.

FIG. 21. Heterotypic spindle in megaspore mother-cell.

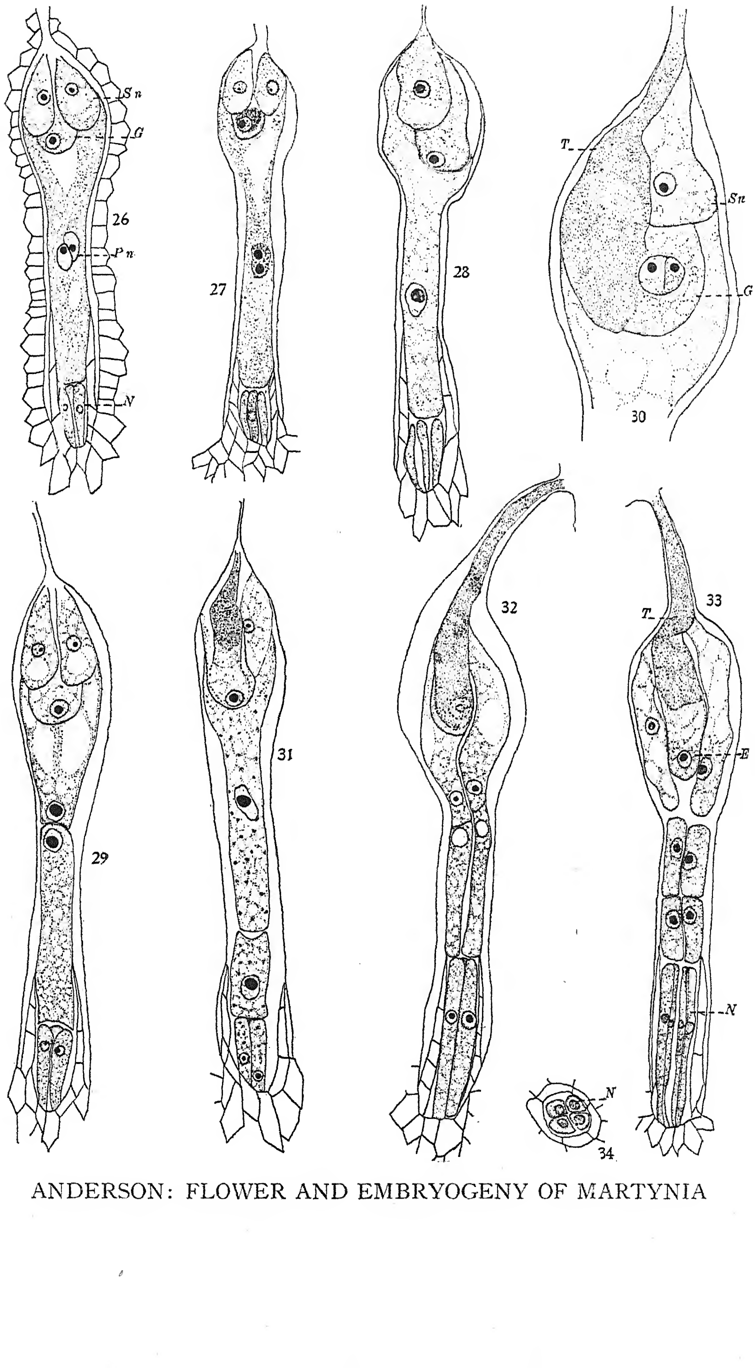
FIG. 22. Tetrad, the upper three potential megaspores disorganizing. Nutritive jacket formed from the layer of integument adjacent the nucellus.

FIG. 23. Section of young ovule showing the single integument and first division of the megaspore; the upper three potential megaspores disorganizing.

FIGS. 24 and 25. Further development of the megaspore; the central portion of nucellus disorganizing.



ANDERSON: FLOWER AND EMBRYOGENY OF MARTYNIA



ANDERSON: FLOWER AND EMBRYOGENY OF MARTYNIA

PLATE 8

FIGS. 26–33, longitudinal sections of embryo-sacs. FIG. 34, cross section of antipodals.

FIG. 26. Mature embryo-sac; polar nuclei side by side near the center of the sac; G, egg-cell; Sn, synergid; N, antipodals; Pn, polar nuclei, × 300.

FIG. 27. Mature embryo-sac; polar nuclei fusing, × 300.

FIG. 28. Mature embryo-sac; polar nuclei fused, × 350.

FIG. 29. Endosperm two-celled; egg not yet fertilized, × 350.

FIG. 30. Fertilization. Sperm and egg nuclei in contact; old pollen tube quite prominent; G, egg-cell; T, pollen tube; Sn, synergid, X 740.

FIGS. 31 and 32. Development of endosperm and elongation of antipodals, X 350.

FIG. 33. Development of endosperm and embryo; four antipodals, N; E, elongating embryo; T, old pollen tube, × 350.

FIG. 34. Cross section of chalazal end of embryo-sac showing four antipodals, N, × 350.

INDEX TO AMERICAN BOTANICAL LITERATURE
1921

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Reviews, and papers that relate exclusively to foresty, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Vol. 49 No. 6

BULLETIN

OF THE

TORREY BOTANICAL CLUB

JUNE, 1922

Mycological notes for 1920*

L. O. Overholts

(WITH PLATE 9 AND FOURTEEN TEXT FIGURES)

1. Zythia resinae (Ehrenb.) Karst.

For several years there has been noted in the mountains near State College a small inconspicuous fungus always confined to resin exudate on species of two- and three-needle pines. It has been found especially abundant in the vicinity of Charter Oak and Greenwood Furnace, Pennsylvania. Its habitat is the resin mass inhabited by the larvae of the "pitch midge," *Cecidomyia resinicola* Osten-Sacken. The origin of the resin exudate has not been studied by the writer, but E. P. Felt† states (on the authority of Miss L. S. Eckel) that the resin flow from the tree is not the result of an injury caused by the midges, but that they "take advantage of normal exudations of resin on which to oviposit," although "the flow of this substance may be increased to some extent by the larvae rasping the living tissues." At any rate the final resin masses are subglobose or depressed globose and 1.5–2.5 cm. in diameter (Plate 9, fig. 2). They may occur on one side of the limb only, as stated and illustrated by Felt, or the exudate may entirely encircle the limb, though I have seen no instances of the saccate type of resin mass illustrated by Felt. These masses are in

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†N. Y. State Mus. Memoir 8: 410–412. 1906.

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all cases found near the ends of the branches and always at the forks of the twigs.

Eventually the fungus produces its pycnidia on this hardened and blackened resin mass. These are minute elongate-ovoid or almost conical bodies (PLATE, 9, FIG. 1, at left), yellow or amber-colored, and large enough to be easily visible, on close inspection, to the unaided eye. The ostiole is usually quite prominent, and may often be seen with a hand lens. In texture the pycnidia are waxy and easily crushed when mounted in water. The spores are globose, smooth, hyaline, and very small, measuring only about 2 μ in diameter.

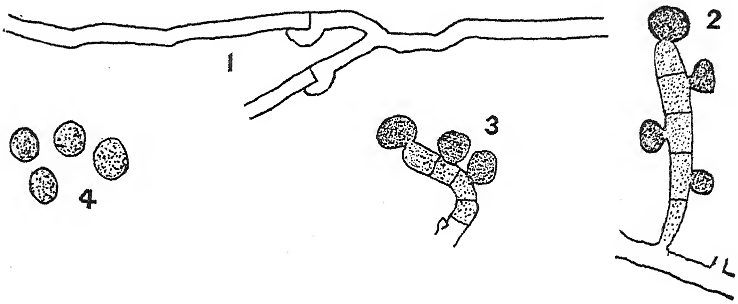
The nature of the pycnidium places the fungus in the Nectrioidaceae of the Fungi Imperfecti. After several unsuccessful attempts at identification, the species was determined for me as *Zythia resinae* by Mrs. F. W. Patterson, who wrote that my specimens represented the only American material she had seen. Later Dr. Seaver identified my plants as being the conidial stage of *Nectriella resinae* (Fr.) Sacc., as listed by Saccardo. *Nectriella* is a genus of the true Nectriaceae, order Hypocreales, and consequently with an ascus in the life history. Examination of material collected at various times over a period of several years has failed to show on the same substratum any ascospore-producing structure comparable to the perithecium of a *Nectriella*. There is produced, however, on the same resin masses that bear the pycnidia an apothecial fructification that has been referred to *Biatorella resinae* (Fr.) Mudd., as listed below.

2. BIATORELLA RESINAE (Fr.) Mudd.

In company with *Zythia resinae*, as described above, there frequently grows an apothecial fruiting body that was determined as *Biatorella resinae* by Dr. L. W. Riddle, to whom my specimens were sent by Dr. Seaver. The very small apothecia are about 1 mm. in diameter and yellowish or amber-colored (PLATE 9, FIG. 1, at right). They have been collected on resin exudate inhabited by the larvae of the "pitch midge" on *Pinus virginiana* at Charter Oak and on *P. ponderosa* at Greenwood Furnace. The curious habitat and the frequent association of these apothecia with the pycnidia of the *Zythia* suggest a connection between the two, but if the *Zythia* is the pycnidial stage of the *Nectriella* such could hardly be the case.

3. PILACRE PETERSII B. & Br.

This rare species was found for the first time in the writer's experience on a dead snag of *Acer rubrum*, July 1, 1920, on Stone Creek, Huntingdon County, Pennsylvania. Hundreds of the small brown stipitate fruiting heads were present on a small area (PLATE 9, FIG. 4), and their abundance suggested that this species is probably not so rare as has been supposed but, because of its small size and inconspicuous coloration, is usually



FIGS. 1-4. PILACRE PETERSII B. & Br.

1. Hyphae with clamp connections. 2 and 3. Basidia with spores. 4. Spores.

overlooked. Cross-septate basidia characteristic of the Auriculariales are always difficult to demonstrate, but the writer has located them with more ease in this species than in any other, though not readily demonstrable at best (TEXT FIGS. 2 and 3). The fungus departs widely in consistency and habit from other members of the order. The following descriptive notes are appended:

Sporophores gregarious on the substratum, sometimes growing from a slight superficial gray mycelium, 2–5 mm. high, consisting of a slender stalk bearing a single subglobose or hemisphaeric head; head 0.5–2.5 mm. in diameter, at first gray-pruinose, then deep brown, covered by a thin membrane that disappears at maturity, filled with a brown spore mass mixed with hyphae and powdery at maturity; spores sessile on the basidia, subglobose, smooth, brown, 5–7.5 μ diameter; basidia transversely three-septate (four-celled), hyaline, straight or curved, produced laterally on somewhat larger hyphae, 15–24 μ long, 2–3 μ in diameter, the terminal cell bearing its spore apically, the other cells each with a lateral spore produced on either side of the basidium if straight, but on the convex surface if curved; hyphae hyaline, then brown, somewhat branched, with cross walls and clamp connections, 2–3 μ in diameter;

stem central, grayish white, 0.2–0.35 mm. in diameter. [TEXT FIGS. 1–4.]

On dead wood of deciduous trees.

4. TULASNELLA VIOLAE (Quél.) Boud. & Gal.

The genus *Tulasnella*, recently monographed for this country by Burt, is an anomalous genus, *Corticium*-like in appearance, but hardly so in structure. It is characterized by the presence of large sterigmate-like processes, four in number (usually), that are produced on a basidium-like organ, and that in turn bear each a hyaline spore. Only three species are listed by Burt, all of narrow geographical range and none hitherto reported from Pennsylvania.

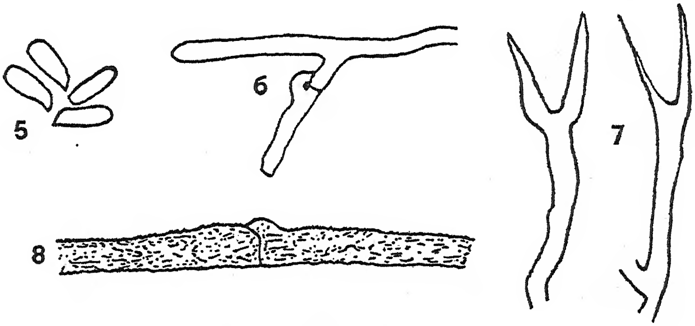
A small collection of *T. Violae* was made in the mountains of Center County, Pennsylvania, on January 29, 1921, on the inside of a gum (*Nyssa sylvatica*) log by the writer's mycology class while on a collecting trip. The discovery of the specimens is credited to Mr. W. A. Kuntz.

The color of these specimens was flesh pink or livid pink (Ridgway) when collected, but it is not probable that they will long retain these colors in the herbarium. In aspect the plants resemble very much a thin species of *Corticium*, and casual observations of free hand sections show nothing very different from sections of species of that genus. Spores were abundant in the collection, however, and it was only when the usual attempt was made to substantiate their connections to basidia that the real nature of the hymenium became apparent. With some difficulty the large clavate or elongate sterigmata were made out, sometimes four in number and sometimes apparently but three. After the development of the sterigmata the basidia appear to collapse, or at least in a spore-bearing condition the group of sterigmata is so large as to give this impression. The spores are broadly ellipsoid to globose, and in these specimens have two or three large conspicuous guttulae The spores measure 5.5–7.5 x 5 μ. No cystidia are present.

5. DACRYOMYCES HYALINA Quél.

The species of the genus *Dacryomyces* are not well known in this country, partly because, in spite of their usually bright colors, they dry down and are rather inconspicuous in dry weather, when collectors are most likely to be in the field. *D. hyalina*, as determined for me by C. G. Lloyd in 1919, was

found for the first time in Pennsylvania on January 29, 1921, on a fallen log of *Pinus Strobus*. The dried plants appear as small scaly growths, dark in color, but when wet they swell up and take on a more waxy appearance and gelatinous texture. Fresh specimens measure 1–2 mm. in diameter, or by confluence as much as 3 mm. The color is a waxy yellow in young specimens, verging to olivaceous or brownish when dried. The fructification is almost disk-shaped, being considerably flattened, and the upper surface may be smooth or thrown into serpentine folds. The hymenium is composed of the usual bifurcate basidia (TEXT FIG. 7), each with two spores. The spores (TEXT FIG. 5) are short-cylindric though often narrowed at one end, hyaline, one-celled, and measure 10–12 x 3–4 μ. The hyphae in



FIGS. 5–8. DACRYOMYCES HYALINA Quél.

5. Mature spores. 6. Hypha with clamp connection. 7. Mature basidia. 8. Hypha with scabrous wall and clamp connection.

the trama vary from 4 μ to 6 μ in diameter and the walls of the larger ones appear scabrous. Branching and anastomoses are common, but cross walls are not abundant. Contrary to the usual condition in the Tremellales and the Dacryomycetales, clamp connections are found on the hyphae, though not abundant. On the older scabrous hyphae they are rather inconspicuous (TEXT FIG. 8) but on the younger hyphae they are not difficult to locate (TEXT FIG. 6).

Good figures of this plant were recently published by Lloyd (Myc. Notes, No. 58, p. 828. 1919), who reports the species from North Carolina. The name employed to designate the species is open to criticism. The plants seem to be specifically distinct from *D. deliquescens*, which they resemble microscopically as to spores and basidia, since the latter seems to lack the large

scabrous-walled hyphae and the clamp connections of *D. hyalinus*. I have not made, for *D. deliquescens*, an exhaustive search for clamp connections, but have failed to find them in the mounts I have made. Neither have I ever seen *D. deliquescens* assume the dark colors on drying, characteristic of the present species.

6. STEREUM RADIATUM Peck

The fourth Pennsylvania collection of this species was made in October 27, 1920, on coniferous boards in the greenhouse at State College. A fifth collection, made in the Ottawa Valley, Canada, by R. J. Blair in 1917, is in my herbarium. Three of these collections were taken from structural coniferous timbers, four of them being from *Tsuga canadensis*. The specific identity of the substratum of the fifth collection was not determined, except that it was recognized as a coniferous host. The first collection, made here in 1915, was determined by Dr. Burt.

The species is one of the easiest of the stereums to recognize. The plants are almost entirely resupinate and the hymenium is in all collections a uniform cinnamon brown or Sudan brown, except that where the fresh specimens are wounded on the hymenium they immediately turn black and remain so on drying. The hymenial surface is radiately lined with obtuse ribs in all cases. The pileus where developed is black on top in dried specimens and usually decidedly rugose.

Spores have not been certainly seen; in one specimen, however, small rounded hyaline spore-like bodies, 4–5 μ in diameter, were present on the hymenium but were not seen attached to basidia. No cystidia are present. Sections of the hymenium sometimes become pea green in KOH solution.

7. MERULIUS FUGAX Fr.

This rare and interesting species was collected on a coniferous board in the greenhouse at the Pennsylvania State College, on October 26, 1920. It is a bright colored species, my field notes recording a salmon buff color, varying to pinkish cinnamon for the hymenial surface, and with the margin considerably lighter. The specimen was rather young and the gyrose-plicate hymenium was developed only in the center of the fructification. The plant is separable from the substratum when fresh but as soon as it becomes dry it adheres tightly, although the fructification is quite membranous in that condition. Microscopic examination of sections through it shows the character-

istic features of the species, which are the oblong-ellipsoidal to subglobose spores and the large conspicuously incrusted hyphae of the subhymenium next the substratum. These hyphae are 4–6 μ in diameter and possess both cross walls and clamps. The spores under the microscope are all but hyaline, although the species is included among the *Leptospori* by Dr. Burt, who states that they sometimes appear slightly yellowish. No cystidia are present.

Merulius subaurantiacus Peck is recorded as a synonym by Dr. Burt, and my sections of the type of that species show structures identical with those of *M. fugax*, except that no incrusted hyphae are present next the substratum. Apparently no other species described from America has similar spores.

8. SOLENIA FASCICULATA (Pers.) Fr.

Plants rather crowded on decorticated wood, consisting of isolated cylinders not more than 1 mm. high and 0.2 mm. thick, whitish or slightly brownish, externally compactly tomentose; hymenium lining the hollow cylinders, of clavate basidia without cystidia; spores not seen attached to basidia but free-floating, hyaline, thin-walled, and 5–7 μ in diameter.

On coniferous wood. Reitz Gap, Center County, Pennsylvania, September 20, 1920, *J. F. Adams*.

According to C. G. Lloyd, who made the determination, *S. villosa* Fr. is probably the same species. These specimens depart from the available descriptions of *S. fasciculata*, which call for a plant 2–7 mm. high. The plants under the hand lens (PLATE 9, FIG. 3), resemble a simple *Mucronella* in which genus, however, the basidia are external.

9. POLYPORUS CAERULOPORUS Peck

Collected on the banks of Stone Creek, Huntingdon County, Pennsylvania, July 9, 1920.

A rare species, listed by Murrill as occurring in New England and New York. The uniform pale indigo-blue color of cap, tubes, and stem is unique among the pore fungi. A single specimen was collected, from which the following notes were made:

Plant stipitate, more or less uniformly pale indigo-blue; pileus nearly orbicular, 4.5 x 3.5 x 0.3–0.7 cm., smoky indigo, glabrous, dry, slightly rugose; margin lobed, deflexed; context white, 1–5 mm. thick, taste mild; tubes about 2 mm. long, pale blue within, the mouths pale indigo-blue, angular, thin-walled, entire, averaging two per mm., decurrent on the stem,

not separable from the context; stem excentric, nearly lateral, deep indigo-blue, pallid within, glabrous, 2.5 cm. long, 0.5 cm. thick; spores subglobose, hyaline, 4–5 μ in diameter; cystidia none.

The dried plant is dark bluish black on the pileus and stem, and the hymenium has become brown.

10. **Polyporus compactus** sp. nov.

Plants resupinate to narrowly reflexed or cushion-shaped, the pileus not more than 1 cm. broad, and 1.5 cm. thick, in resupinate condition 3–8 mm. thick, white or gray in color, corky-watery when fresh, firm and compact when dry, glabrous or practically so, the margin rounded and obtuse; context light wood color, friable but compact when dry, taste mild; tubes oblique, less than 2 mm. long, often lacking or poorly developed, the mouths subcircular, averaging three or four per mm., white; dissepiments rather thick and rigid; basidiospores ellipsoid or ovoid, often with a slightly truncate apex, hyaline, 7.5–9 x 4.5–6 μ; chlamydospores (?) abundant on the hymenium and the hyphae of the context, subglobose to broadly ellipsoid, colorless or somewhat greenish or yellowish under the microscope, 7.5–9 x 6–7.5 μ or 6–7.5 μ in diameter; basidia large, pyriform, 9–10 μ in diameter; cystidia mixed with the basidia as pointed, narrow, flask-shaped organs 3–4 μ in diameter; hyphae of two kinds: (*a*) large hyaline, unstaining hyphae, often thick-walled, abruptly breaking up at one end into several to many smaller branches that gradually taper out to the extremity, 3–5 μ in diameter in the larger portions, lacking cross walls and clamps; (*b*) small deeply staining and much branched hyphae bearing at least some of the chlamydospores, with a few cross walls and clamps, diameter 2–3.5 μ. [PLATE 9, FIGS. 5 and 6; TEXT FIGS. 9–14.]

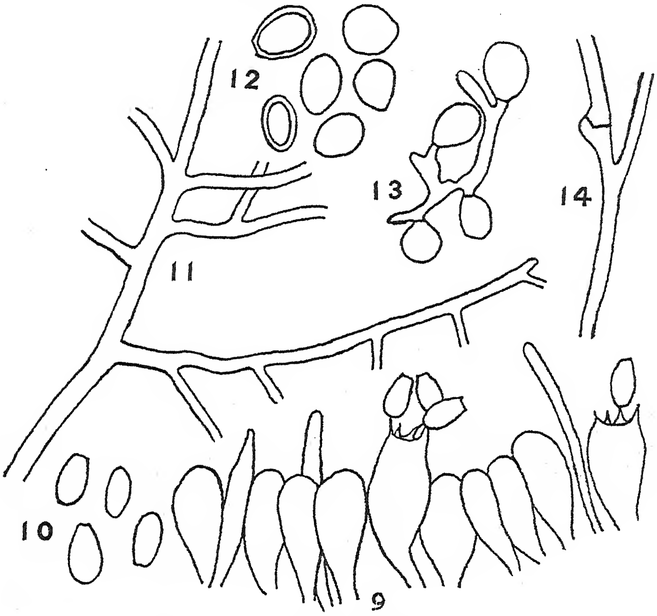
On dead standing trunks or on stumps of *Quercus*, especially *Q. alba*.

Specimens are at hand as follows, the first mentioned being designated as the type:

New Brunswick, New Jersey, on dead standing *Quercus alba*, August 25, 1920, *Overholts & West*, No. 7873; Lamar, Clinton County, Pennsylvania, on dead standing *Quercus alba*, July 26, 1920, Overholts Herb. No. 7525; State College, Pennsylvania, on oak stump, October, 1920, No. 7173; New Brunswick, New Jersey, on dead *Quercus alba*, August 21, 1918, *E. West 343*, No. 7584; New Brunswick, New Jersey, on dead standing oak trunks, June 16, 1919, *E. West* 414, No. 7526.

After this manuscript was submitted for publication, the specimens that had been previously designated as the types and from which the photographs for this article were made, were

destroyed by a fire that burned the photographic studio where the collection was kept at the time. This has necessitated designating my herbarium No. 7873, as the type of the species rather than No. 7525, from which the photographs were made, and which is therefore no longer in existence. This will explain any discrepancy that might appear in the failure, in later years, to find a collection in my herbarium with the exact aspect presented in the photographs.



FIGS. 9–14. POLYPORUS COMPACTUS Overholts

9. Small portion of the hymenium showing basidia, cystidia, and attached spores. 10. Mature basidiospores. 11. Branched hypha. 12. Chlamydospores. 13. Production of chlamydospores. 14. Hypha with clamp connection.

Of the collections here cited, only the first and the last named show basidia and basidiospores, while all bear the chlamydospore condition.

The real status of the so-called chlamydospore condition has not been determined, as no cultures have been attempted. That the knob-like growths as shown in PLATE 9 involve this species can scarcely be questioned. It has been suggested that these growths may represent a diseased condition and that the bodies here designated as chlamydospores may be in reality the spores

of the parasite. They are not produced in chains but formed singly as the termini of small hyphae deeply staining with eosin.

This fungus has been under careful observation for several years, but only the chlamydospore condition was known until 1920. A well-developed pileus is never present. In some respects the species shows resemblance to *P. Ellisianus* Murrill, which however is found on coniferous wood and has entirely different spores. The cushion-shaped or nodular type of sporophore, bearing only the chlamydospore condition, has the context more or less zoned and with a disagreeable odor as of strong lard.

11. FOMES BAKERI Murrill

I found this species to be quite common, by far the most common species of *Fomes*, in the vicinity of Kingston, New Jersey, where I observed it in company with Mr. E. West in August, 1920. Its only host in that locality is the river birch, *Betula nigra*, which is its host also in the Mississippi Valley. The species was described and illustrated in my notes for 1919, where reference was made to a collection said to have been taken from *Betula lutea* near Philadelphia in 1915 by Rhoads. In all probability the host for this collection was *B. nigra*, as *B. lutea* is not found in that locality, according to Dr. Rhoads.

In connection with this species it was of interest to find recently in the Schweinitz Herbarium at Philadelphia a specimen of *Fomes* under the name of *Polyporus annosus* Fr. (Syn. N. Am. Fungi No. 401) that is undoubtedly *F. Bakeri*, although it seems not to have been recognized by those who have worked over the Schweinitzian material in recent years. Lloyd once referred this specimen to *F. rimosus*, noting, however, its similarity to *F. robustus* Karst., which he has subsequently regarded as identical with *F. Bakeri*. This Schweinitzian collection bears no date but was made certainly prior to 1831 and was listed by Schweinitz as occurring on *Betula*.

12. PHALLOGASTER SACCATUS Morgan

A rare plant, placed in the *Phallaceae* by some largely on the foetid nature of the internal deliquescent gleba, but in appearance more allied to the Lycoperdaceae. Two specimens were collected at Westport, Pennsylvania, August 11, 1920. Excellent illustrations, by which the plant may readily be known, have been published by Lloyd.

Explanation of plate 9

FIG. 1, Enlarged photograph of a small area of the resin exudate on which *Zythia resinae* (Ehrenb.) Karst. and *Biatorella resinae* (Fr.) Mudd. grow side by side. The elongate bodies in the left hand corner are the pycnidia of the *Zythia*, while the larger disk-shaped bodies to the right are the apothecia of the *Biatorella*. Photographed with Micro-Tessar 10 × lens, by E. T. Kirk.

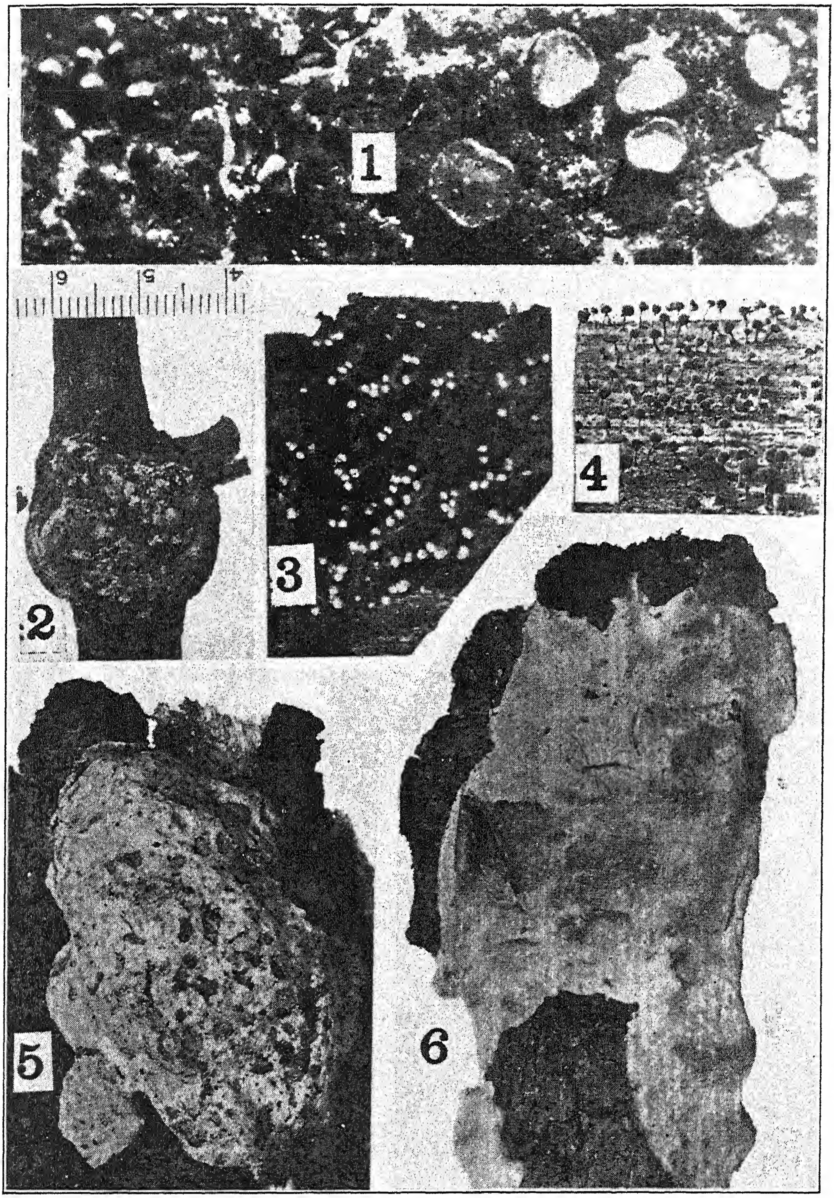
FIG. 2, Resin exudate inhabited by the pitch midge and bearing the fruiting bodies of *Zythia resinae* and *Biatorella resinae*, × 1. Photo by the writer.

FIG. 3, *Solenia fasciculata* (Pers.) Fr., showing the isolated white-tipped cylinders in which the hymenium is produced. Photographed with Micro-Tessar 10 × lens, by C. B. Neblette.

FIG. 4, *Pilacre Petersii* B. & Br., natural size, Photo by the writer.

FIG. 5, Rounded abnormal growth of *Polyporus campactus* Overholts, as usually found on vertical surfaces, and bearing only the chlamydospore condition, × 1. Photo by the writer.

FIG. 6, Poroid form of *Polyporus compactus*, showing the largely resupinate manner of growth, × 1. Photo by C. B. Neblette.



1, 2. ZYTHIA RESINAE (EHRENB.) KARST. AND BIATORELLA RESINAE (FR.) MUDD.
3. SOLENIA FASCICULATA (PERS.) FR.
4. PILACRE PETERSII B. & BR.
5, 6. POLYPORUS COMPACTUS OVERHOLTS

Unreported plants from Glacier National Park

Paul W. Graff

Our national parks are each season attracting a greater number of vacationists drawn to them by the beauties of nature, some only by the great attractions of mountain scenery but many by all the varying phases of nature to be enjoyed in these national playgrounds. To the person of botanical or zoological interests Glacier Park is one of the most attractive. Its high rugged peaks, deep valleys, numerous glaciers and lakes, streams and cascades offer a great amount of variation. The Continental Divide passes through the Park with the result that the drainage of the western portion is into the Columbia River, while the northeastern part slopes toward the Hudson Bay, and the eastern into the Missouri River drainage. A greater amount of variation will be found here and with less sophistication than in any other of our park areas.

In the herbarium of the University of Montana Biological Station at Yellow Bay are a number of plants which have been collected at the Park. Among these are a number which have not as yet been reported from that region even in Standley's recent publication.* The present list is offered as an addition and slight contribution to the knowledge of the flora of this region. Of the thirty-two species here listed twelve have not before been reported from the state of Montana. The names of these twelve are preceded by a dagger (†). Two of these, *Carex Heleonastes* Ehrh., and *Salix reticulata* L., have not, so far as I am aware, been reported from the United States. They are Canadian species which have entered this country in the high mountains of this region, both being extreme northern forms.

† 1. Danthonia pinetorum Piper, Fl. Northw. Coast 46. 1915. *D. spicata* var *pinetorum* Piper, Erythea **7**: 103. 1899. *D. thermalis* Scribn. U. S. Dept. Agr. Div. Agrost. Circ. 30: 5. 1901.

Mineral Park, August 10, 1910, *M. E. Jones*, at 1800 meters elevation.

This is a northwest coast plant which has been reported as

*Flora of Glacier National Park. Contr. U. S. Nat. Herb. **22**: 235–438. *pl. 33–52.* 1921.

being found to the eastward in Wyoming and Idaho, but not as yet in the state of Montana.

2. POA CUSICKII Vasey, Contr. U. S. Nat. Herb. **1**: 271. 1893.

Mineral Park, August 8, 1910, *M. E. Jones*, at 2400 meters elevation.

Reported from British Columbia, south to Oregon and eastward through Idaho and western Montana.

3. POA NEVADENSIS Vasey, Bull. Torrey Club **10**: 66. 1883.

Greenwood's Camp, August 15, 1910, *M. E. Jones*, at an elevation of 1350 meters.

Reported from British Columbia southward to Arizona, and eastward to North Dakota and Colorado.

4. BROMUS EXIMIUS (Shear) Piper, Contr. U. S. Nat. Herb. **11**: 143. 1906. *B. vulgaris* var. *eximius* Shear, U. S. Dept. Agr. Div. Agrost. Bull. 23: 44. 1900.

Greenwood's Camp, August 15, 1910, *M. E. Jones*, at 1350 meters elevation.

This is primarily a Pacific coast plant, being found from British Columbia southward to California. To the eastward of this range it is found in the states of Montana and Wyoming.

5. ERIOPHORUM POLYSTACHYON L. Sp. Pl. 52. 1753.

Mineral Park, August 12, 1910, *M. E. Jones*, at 1800 meters elevation.

This is primarily a Canadian species which has been found to the southward in the Rockies and in the North Atlantic States.

† 6. CAREX AQUATILIS Wahl. Kongl. Vet. Akad. Handl. II. **24**: 165. 1903.

Bowman Lake, August 19, 1910, *M. E. Jones*, at 1200 meters elevation; Grinnell Glacier, August, 1911, *M. J. Elrod*, at 2100 meters elevation.

A Pacific coast and Canadian species, also reported southward in the Atlantic States.

7. CAREX DEWEYANA Schwein. Ann. Lyc. New York **1**: 65. 1824.

Waterton Lake, August 17, 1910, *M. E. Jones*, at 1200 meters elevation.

This is a northern species with a range extending southward in both the Appalachians and Rockies. It has been reported from Montana, but not from the Park region.

8. CAREX FESTIVA Dewey, Am. Jour. Sci. **29**: 246. 1835.

Sperry Glacier, August 27, 1909, *M. E. Jones*, at 2250 meters elevation; Grinnell Lake, August 10, 1911, *M. J. Elrod*, at 2100 meters elevation.

Found from California to the Arctic regions on the coast, and in the Rocky Mountains

†9. CAREX FOENEA Willd. Enum. 957. 1809.

Waterton Lake, August 17, 1910, *M. E. Jones*, at an elevation of 1200 meters

This is primarily a Canadian species which has crept down into our range. Its range is from New Brunswick to Pennsylvania, thence northwestward to Minnesota, British Columbia, and the Yukon.

10. CAREX GOODENOVII J. Gay, Ann. Sci. Nat. II, **11**:191. 1839.

C. caespitosa Gooden., Trans. Linn. Soc. **2**: 195. *pl. 21*, 1794. Not Linn. 1753.

Lake Mc Donald, August 2, 1910. *M. E. Jones*, at 900 meters elevation. Mineral Park, August 10, 1910, *M. E. Jones*, at an altitude of 1800 meters.

Found from Newfoundland and Pennsylvania westward to Alaska and Colorado.

† 11. CAREX HELEONASTES Ehrh.; L. f. Suppl. 414. 1781.

Sperry Glacier, August 27, 1909, *M. E. Jones*, at an altitude of 2250 meters, growing in a damp locality among moss.

While reported from the Upper Temperate and Alpine Life Zones in Canada, from Ontario and the Hudson Bay region westward to British Columbia, this species does not seem to have been reported from this side the "Border." It is essentially a northern plant which has found its way into the United States in the high altitudes of the Park.

†12. CAREX HORMATHODES Fernald, Rhodora **8**: 165. 1906.

Blackfoot Glacier, August 30, 1909, *M. E. Jones*, at 2100 meters elevation.

Reported previously from British Columbia, but not from the northwestern United States.

†13. CAREX MONILE Tuckerm. Enum. Meth. 20. 1843.

Grinnell Lake, August 20, 1911, *M. J. Elrod*, at 1500 meters elevation.

This differs from *C. vesicaria* L., with which it is sometimes confused, in the possession of three stigmas rather than two and in the presence of more than one staminate spike. The variety *colorata* Bailey has been reported from Yellowstone

Park, but the typical form of the species has not been reported from Montana.

Reported south of our range in Wyoming, and across the United States. It is also found along the Pacific coast from California to Alaska.

†14. CAREX POLYGAMA Schkuhr, Riedgr. 1: 84. 1801.

Waterton Lake, August 17, 1910, *M. E. Jones*, at an elevation of 1200 meters.

Reported well to the northward on both coasts, and across the United States from California through Utah, Colorado, and Missouri to the Atlantic coast. It is a southern species which has found a congenial habitat to the northward on both seaboards.

†15. CAREX SAXATILIS L. Sp. Pl. 976. 1753.

Bowman Lake, August 19, 1910, *M. E. Jones*, at 1200 meters elevation.

C. saxatilis is an arctic species found across North America from Labrador to Alaska. It has been reported as entering the United States in the mountainous portion of Maine, but has not been reported from the western states except in the high mountains of Colorado. It is essentially an arctic plant, and is found also in the extreme northern portion of Europe and Asia.

16. SALIX ORBICULARIS Anders.; De Candolle, Prodromus **16^2:** 300. 1868.

Flat-top Mountain, August, 1911, *M. J. Elrod*, at 1900 meters elevation; Iceberg Lake, August 18, 1911, *M. J. Elrod*, at 1800 meters elevation.

Reported previously from the Sperry Glacier region under the name *S. reticulata* L.

This is an extreme northwestern species found from Alaska to Hudson Bay, and southward into the United States in the Rocky Mountains.

†17. SALIX RETICULATA L. Sp. Pl. 1018. 1753. Not Porter & Coulter.

Blackfoot Glacier, August 31, 1909, *M. E. Jones*, at an elevation of 2100 meters.

This species has been considered previously as purely Canadian. It has been reported from the Canadian Rockies and northward to Alaska and Hudson Bay. *Salix saximontana* Rydb. has been reported from this region with *S. reticulata* L.

as a synonym, an error for *S. reticulata* Porter & Coulter, a quite distinct species.

18. ERIOGONUM OVALIFOLIUM Nutt. Jour. Philad. Acad. **7**: 50. *pl. 8*. 1834.

Brown's Pass, August 13, 1911, *M. J. Elrod*, at 2580 meters elevation.

A western species found from New Mexico northward through California and Colorado to British Columbia.

19. POLYGONUM BISTORTOIDES Pursh, var. LINEARIFOLIUM (Wats.) Small, Bull. Torrey Club **19**: 252. 1892.

Iceberg Lake, August 18, 1911, *M. J. Elrod*, at an elevation of 1800 meters.

Found from New Mexico northward within the Rocky Mountains through Canada to the Arctic regions.

20. SILENE DOUGLASII Hook. Fl. Bor. Am. **1**: 88. 1840.

Sperry Glacier, August 27, 1909, *M. E. Jones*, at 2250 meters elevation.

Rather a common plant in the Rockies, and on the coast from Washington to California.

21. ARENARIA SUBCONGESTA (Wats.) Rydb., Bull. Torrey Club **24**: 244. 1897.

Brown's Pass, August 13, 1911, *M. J. Elrod*, at 2580 meters elevation.

This species is common in the Rocky Mountain region. It seems to be the same as *A. lithophila* Rydb. and *A. Burkei* Howell and should possibly be considered only a variety of *A. congesta* Nutt.

22. ARAGALLUS MONTICOLA (Gray) Greene, Pittonia **3**: 212. 1897.

Mineral Park, August 8, 1910, *M. E. Jones*, at 2100 meters elevation; Brown's Pass, August 13, 1911, *M. J. Elrod*, at 2580 meters elevation.

Not uncommon in the mountains from Wyoming northward.

23. POLEMONIUM CONFERTUM Gray, Proc. Acad. Philadelphia **1863**: 73. 1864.

Brown's Pass, August 13, 1911, *M. J. Elrod*, at 2580 meters elevation.

A high elevation plant found in the mountains of Utah, Colorado, Wyoming, and Montana; occasionally in northern New Mexico and California.

24. PHACELIA FRANKLINII (R. Br.) Gray, Manual, Ed. 2, 329. 1856.

Mineral Park, August 8, 1910, *M. E. Jones*, at 2400 meters elevation; Brown's Pass, August 13, 1911, *M. J. Elrod*, at 2580 meters elevation.

From southern Idaho, Wyoming, and Michigan northward to Hudson Bay and Alaska.

† 25. LAPPULA CILIATA (Dougl.) Greene, Pittonia **2**: 182. 1891.

Mineral Park, August 12, 1910, *M. E. Jones*, at 1800 meters elevation.

Reported from the states of Washington and Idaho.

26. PENTSTEMON MENZIESII Hook. Fl. Bor. Amer. **2**: 98. 1840. *P. fruticosus* (Pursh) Greene, Pittonia **2**: 239. 1892.

Sperry Glacier, August 27, 1909, *M. E. Jones*, at 2250 meters elevation; Brown's Pass, August 13, 1911, *M. J. Elrod*, at 2580 meters elevation.

Found from California and Colorado northward to British Columbia and Alberta.

† 27. VERONICA CUSICKII Gray, Syn. Flor. **2**: 288. 1878.

Mineral Park, August 9, 1910, *M. E. Jones*, at 1800 meters elevation.

Previously reported only from the high mountain regions of the three states, Washington, Oregon, and Idaho.

28. VALERIANA OCCIDENTALIS Heller, Bull. Torrey Club **25**: 269. 1898. *V. sylvatica* Banks; Richards, Frankl. Journ. Ed. 2, Appendix 2. 1823. Not Schmidt, 1795. *V. wyomingensis* E. Nels. Erythea **7**: 167. 1899.

Swift-Current Pass, August 11, 1910, *M. E. Jones*, at 2100 meters elevation.

Found from Labrador and Quebec across Canada to British Columbia, and southward through Washington and Montana to Colorado and Utah.

29. SOLIDAGO PURSHII Porter, Bull. Torrey Club **21**: 311. 1894. *S. humilis* Pursh, Fl. Am. Sept. 543. 1814. Not Mill.

Brown's Pass, August 13, 1911, *M. J. Elrod*, at 2580 meters elevation; Iceberg Lake, August 18, 1911, *M. J. Elrod*, at 1800 meters elevation.

Found in the Rocky Mountains from New Mexico to British Columbia and northward.

30. ERIGERON GRANDIFLORUS Hook. Fl. Bor. Am. 2: 18. *pl. 123*. 1840.

Sperry Glacier, August 27, 1909, *M. E. Jones*, at an elevation of 2250 meters.

Reported from Colorado to the extreme north; more especially in the high elevations of the Canadian Rockies.

† 31. ANTENNARIA ALPINA (L.) Gaertn. Fr. et Sem. 2: 410. 1791.
Gnaphalium alpinum L. Sp. Pl. 856. 1753.

This is essentially a Canadian species found across the continent from Labrador to Alaska, but extending southward into the United States in the Rockies and Sierras.

32. SENECIO AUREUS L. Sp. Pl. 870. 1753.

Brown's Pass, August 13, 1911, *M. J. Elrod*, at 2580 meters elevation; Iceberg Lake, August 18, 1911, *M. J. Elrod*, at 1800 meters elevation.

This species is close to Rydberg's *S. crocatus* of Colorado, Wyoming, and the northern Rockies. Its range is from Alaska to California, and across the continent.

UNIVERSITY OF MONTANA BIOLOGICAL STATION,
YELLOW BAY, MONTANA

Two new plants from western Colorado

GEO. E. OSTERHOUT

Nuttallia marginata sp. nov.

Seemingly a biennial, the stem 3 dm. or more high, white, smooth below, roughish pubescent above, the branches alternate, the lower ones elongate; the lower leaves oblanceolate, sinuate dentate, 6–8 cm. long, 5–7 mm. wide, seesile by a narrow base, the upper leaves smaller, coarsely dentate, sessile, all of them roughish with a barbed pubescence; the flowers yellow, numerous in a cyme of alternate branches, the whole flower—capsule and petals —2 cm. long, sometimes subtended by a narrow entire bract, five outer petals 13 mm. long, the claws short and broad, the upper portion ovate, pointed, the outside pubescent, five inner petals smaller, spatulate; the capsule 8–11 mm. long, rounded at the base, harshly pubescent; the sepals lanceolate, 7 mm. long, pubescent like the capsule; the style 10 mm. long, stigmatic at the tip; seeds many, slightly over 2 mm. long, 1.5 mm. wide, the margin very narrow.

The only locality where I have collected this *Nuttallia* is De Beque, in Mesa County, on the hills north of the town. The type specimens (No. 5842) were collected August 22, 1918. The species begins to blossom near the first of June. It is peculiar in its narrowly margined seeds and pubescent petals.

Acrolasia humilis sp. nov.

Annual, 1–1.5 dm. high, the stem white, smooth below, pubescent with slender barbed hairs above, the first branches from near the base, but the branches few and distant; the lowest leaves spatulate, on short petioles, 3–5 cm. long, 5 mm. or more wide, the succeeding leaves sessile, becoming wider and ovate above, about 2 cm. long, all entire and pubescent beneath, glabrous above or nearly so; the first flowers sessile in the axil of the branches, the later ones clustered and sessile at the ends of the branches, the petals five, yellow, broadly obovate, veined, 2.5–3 mm. long, the calyx lobes linear, 2 mm. long; the stamens ten to fifteen, the filaments slender, the anthers globose; the capsule becoming about 1 cm. long, 3 mm. wide, rough with small barbed pubescence, and longer slender hairs not barbed; the seeds prismatic and minutely muricate.

The type specimens were collected at Grand Junction, on the north side, near the coal mines, May 30, 1921, No. 6086. I also collected it in the vicinity of Eckert, in Delta County. On account of the entire leaves it rather resembles *Acrolasia*

latifolia Rydb. or *A. dispersa* (Wats.) Rydb., but it really belongs with *A. albicaulis* (Dougl.) Rydb. The seeds are similar to the latter, and are in the capsule in three rows, not in a single row and end to end as they are in *A. latifolia* and *A. dispersa*.

WINDSOR, COLORADO

INDEX TO AMERICAN BOTANICAL LITERATURE
1921

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to foresty, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Includes 2 new species of *Siphocampylus*.

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Includes *Sporobolus maximus*, sp. nov.

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Vol. 49 No. 7

BULLETIN

OF THE

TORREY BOTANICAL CLUB

JULY, 1922

New species of Uredineae—XIV*

JOSEPH CHARLES ARTHUR

In the tenth article in this series of new species an error was made in the determination of the host for *Uromyces fuscatus* (Bull. Torrey Club **45**: 142. 1918), which should be *Rumex paucifolius* Nutt., and not "*Polygonum alpinum* All." as printed. It was due to the persistent efforts of Mr. A. O. Garrett, who first thought the host of the collection which he made was *Pentstemon* (see Fungi Utahenses *244*), that the facts in the case were finally established. In July, 1920, Mr. Garrett visited the Utah locality at Gogorza, where he first collected the rust in June, 1915, and secured a flowering stalk of the host, showing it to be *Rumex paucifolius*. Upon my presenting the situation to Professor Aven Nelson, he looked up the field notes and the herbarium specimens collected in Idaho at the same place and time as the type of *U. fuscatus* and came to the conclusion that the host of this collection also was *R. paucifolius*. Only these two localities for the species are known up to the present time.

The correction of these errors was complicated by a similar uncertainty and error in the host names for *Puccinia Polygoni-alpini* Cruch. & Mayor (*Dicaeoma Polygoni-alpini* Arth. N. Am. Flora **7**: 385. 1920), for which only two collections were known at that time, a third one having been added from Greenville, California, since the printing of the Flora. *Rumex paucifolius*, host of the *Uromyces*, can not be told from *Polygonum alpinum*, host of the *Puccinia*, when the fruiting parts are absent, hence the difficulties that have arisen.

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* Contribution from the Botanical Department of Purdue University Agricultural Experiment Station.

[The BULLETIN for June (**49**: 163-188. *pl. 9*) was issued July 8, 1922]

In the twelfth article of this series, under *Puccinia offuscata* (Bull. Torrey Club **47**: 469. 1920), the name *Uredo Zorniae* Dietel (Hedwigia **38**: 257. 1899) should have been given as a synonym. This name was applied to Ule's *2296* from Brazil. Although pycnia have not been seen yet there is circumstantial evidence to indicate that no aecia are produced, and therefore the species is probably a *Bullaria*, and should be called **B. Zorniae** (Dietel) comb. nov. It is a species of the New World, to which the name *Puccinia Zorniae* McAlpine does not apply.

In the same article, under *Pucciniastrum americanum* (Bull. Torrey Club **47**: 468. 1920), *Rubus occidentalis* was erroneously given as a host for this species. The error was called to my attention by Dr. J. J. Davis of the University of Wisconsin, and was confirmed by subsequent examination under the microscope. The type of *P. arcticum americanum* Farl. is on *Rubus neglectus* Peck, collected at Bussey, near Cambridge, Massachusetts. This collection is first mentioned in the original article by Farlow (Rhodora **10**: 16. 1908) as on *R. occidentalis* near Cambridge, but later in the article is referred to as on *R. neglectus*, Bussey, October, 1875. The correction in the name of the host is credited to M. L. Fernald. I have been able to ascertain these facts through the assistance of Dr. R. Thaxter, who has carefully examined the original material in the Farlow Herbarium.

Melampsoropsis roanensis sp. nov.

II. Uredinia hypophyllous, in crowded groups of 2–8 on somewhat discolored spots, roundish or ovoid, 0.3–0.8 mm. long, prominent, early dehiscent by a central or lateral slit, leaving a border or a cap-like covering of epidermis, pulverulent; peridium delicate, uniform in thickness; urediniospores catenulate, ellipsoid, 20–26 by 32–40 μ; wall colorless, 1.5–2.5 μ thick, closely and finely verrucose on one side grading to coarsely verrucose on opposite side with somewhat deciduous cylindric tubercles, 2 μ long.

Telia hypophyllous, in irregular and often confluent groups on reddish spots, roundish or ovoid, 0.5–1 mm. across, elevated, prominent, waxy, orange-red, tardily naked; teliospores cuboid, 16–20 μ broad, almost or quite as long, in a series 65–100 μ long; wall colorless, thin, 1 μ, smooth; contents orange-red.

On *Rhododendron catawbiense* Michx. (Ericaceae), summit of Roan Mountain, Carter County, Tennessee, altitude 6400 feet, July, 1887, II, *R. Thaxter.*

On *Rhododendron punctatum* Andr., LeConte Mountain, Sevier County, Tennessee, altitude 6600 feet, June 8, 1921,

ii, III, *H. F. Bain*, communicated by John A. Stevenson *5812* (type).

The urediniospores of this interesting species are much larger and more prominently verrucose than those of the common form in Europe, *M.* (*Chrysomyxa*) *Rhododendri*. This is the first rust on *Rhododendron* seen from the eastern United States, although the European species has been ascribed to this country by a number of authors. Duggar says (Fungous Diseases 432. 1909), "In the United States this fungus is particularly common in the mountains of the east, and southward as far as the southern limits of the Appalachians." The statement does not apply to any true rust on *Rhododendron*. Roan Mountain and LeConte Mountain are about 100 miles apart. The rust was reported abundant on the summit of LeConte Mountain. Mycologists who visit the summits of these mountains and those nearby should be on the lookout for the aecia, which may be expected to occur on species of *Picea*.

Cronartium stalactiforme Arthur & Kern, comb. nov.

Peridermium stalactiforme Arth. & Kern, Bull. Torrey Club **33**: 419. 1906.

This *Cronartium* belongs to a group of three species which have been much confused, both in nomenclature and in structural characters. All three species have uredinia and telia on *Castilleja* and related genera of scrophulariaceous hosts, which are difficult to distinguish except by means of cultures. The aecia of the three species, however, occuring on pine trunks and branches, can be identified with considerable certainty, even by their gross appearance. The aecia of *C. stalactiforme* are confined to the bark and do not produce woody galls. They often extend over considerable areas, and cause little or no swelling. The individual aecia are low and flattened, with a circumscissile dehiscence.

Cronartium filamentosum (Peck) Hedgc. (*Peridermium filamentosum* Peck, 1882) is similar to *C. stalactiforme* in the effect upon the host, but the individual aecia are more elongated, often becoming cylindric, and have noticeable filaments extending from top to bottom through the individual aecia. There are only rudiments of such filaments in *C. stalactiforme*.

Cronartium coleosporioides (Diet. & Holw.) Arth. (*Peridermium Harknessii* Moore, 1876) differs from the two preceding species by producing a woody gall, often of considerable size and

abruptly rising from the healthy tissue. The individual aecia are low and coalesce into a more or less continuous mass, and are entirely without internal filaments.

There has been much confusion regarding the application of the name *Peridermium Harknessii,* owing in the first place to the obscure way in which it was first published*, and in the second place to the later inclusion of the Pacific Coast forms of the very similar *P. Cerebrum,* whose uredinia and telia occur on leaves of oak.

The name was announced at a meeting of the San Francisco Microscopical Society in July, 1876, by J. P. Moore, who exhibited specimens and explained the nature of the fungus, and who read a letter from H. W. Harkness describing the species in an informal but accurate manner. The collection to which the name was applied was made by Harkness and Moore on May 26, 1876, at Colfax, California, which is in Placer county,

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* Our attention was directed to the early history of this name by Mr. E. Bethel in a letter dated January 22, 1922. Through the assistance of Mr. W. M. Hepburn, of the Purdue University Library, and Professor W. C. Blasdale, of the University of California, the following facts have been established.

In the minute book of the San Francisco Microscopical Society this record occurs: "July 20, 1876. Mr. J. P. Moore read a paper written by Dr. H. W. Harkness on a new variety of fungus infesting Pinus ponderosa near Colfax, and he proposed the name Peridermium Harknessii, which was adopted." There is also in the archives of the society a newspaper clipping giving a more extended account of the matter as presented to the society. This clipping, Professor Blasdale has ascertained, came from the issue of the Daily Alta California of San Francisco, of Saturday, July 22, 1876, volume 28. It consists of the Harkness paper in full, and a paragraph stating how Moore proposed the name.

The society did not issue any printed account of its proceedings during this period of its existence, but occasionally, as the subject matter warranted, the secretary transmitted a more or less formal minute to the London Monthly Microscopical Journal. In the issue of that journal for September 1, 1876, an account of the meeting of July 20 is given in the same words used in the newspaper clipping, with three additional paragraphs.

What is referred to as a paper by Dr. Harkness is in the form of a letter to the secretary of the society. It begins with the sentence: "I have today forwarded for the Society's Cabinet a specimen of Peridermium," etc. This type material was destroyed in the great San Francisco fire, being bulky and in a box separate from other type collections, as Mr. Bethel writes, who has consulted the herbarium of the society both before and since the fire, and as stated by Meinecke (Phytopathology **10**: 281. 1920), who also calls attention to the duplicate specimen at the New York Botanical Garden.

about fifty miles west of Lake Tahoe. Harkness says the fungus "appears both on the limbs and trunks of young trees of the variety *Pinus ponderosa*, generally forming a complete circle around the trees, its sporidia appearing as a zone of bright orange yellow. The spores first germinate beneath the cuticle, which it destroys. Owing to the irritation of this presence an abnormal thickening of the cambium is produced, which in turn gives place to an excessive growth of woody fibre. This process being repeated from time to time a large bulbous expansion is soon formed, so that as often occurs a stem of but an inch in diameter is enlarged to that of four or five. Above this bulb the further development of the stem is retarded, or arrested altogether, its place being supplied by a dense tuft of minute branches." Among other matters it is also stated that "in the vicinity of Colfax the fungus appears to be limited to an area of but a few acres in extent. Within that area, however, it is destroying the young growth."

The quotation is taken from the report by the secretary of the San Francisco society sent to the Monthly Microscopical Journal of London, and printed on page 164 in volume 16, bearing the date of September 1, 1876. This periodical was maintained by the Royal Microscopical Society.

The name, host and locality are cited in Harkness & Moore's Pacific Coast Fungi in 1880, still without confusion with any other form. But when Harkness published technical descriptions of "New species of Californian fungi" in the Bulletin of the California Academy of Science in 1884, other forms and hosts were incorporated, and from this time on the application of the name has been various.

The chief source of confusion has been in failing to recognize the Pacific Coast form of *Peridermium Cerebrum* Peck, which occurs along the coast of California, and is especially abundant at Monterey on *Pinus radiata* (*P. insignis*). The present writers feel especially culpable for this confusion, for they placed *P. Harknessii* under *P. Cerebrum* as a synonym in their paper on North American species of *Peridermium* on pine (Mycologia **6**: 133. 1914), and have been followed by Meinecke, in his paper on *Peridermium Harknessii* and *Cronartium Quercuum* (Phytopathology **6**: 225-240. 1916), and by others.

The present knowledge of the *Castilleja* rusts indicates that the correct application of the names should be as follows:

Cronartium filamentosum (Peck) Hedgc. (*Peridermium filamentosum* Peck, 1882);

Cronartium coleosporioides (Diet. & Holw.) Arth. (*Uredo coleosporioides* Diet. & Holw. 1893);

Cronartium stalactiforme Arth. & Kern (*Peridermium stalactiforme* Arth. & Kern, 1906).

Should it be deemed advisable to combine these three species as subspecies, races, or forms, the name to be employed for the aggregate species, using the oldest specific name, would be *Cronartium Harknessii* (Moore) Meinecke, Phytopathology **10:** 282. 1920.

DIABOLE gen. nov.

Cycle of development includes only subcuticular telia, with a possibility of pycnia.

Telia somewhat indefinite in extent, without paraphyses. Teliospores free, usually paired on a common pedicel, one-celled, more or less adhering laterally; wall colored, usually verrucose, at least above; pore one, in upper part of cell.

Diabole cubensis comb. nov.

Uromycladium (?) *cubense* Arth. Mem. Torrey Club **17:** 119. 1918.

The species occurs in Cuba on *Mimosa pigra* L. (*M. asperata* L.) and was at first assigned with many misgivings to the genus *Uromycladium.* That connection has become more and more uncertain, and it is now believed to constitute a new and very distinctive genus.

Puccinia Plucheae (Sydow) comb. nov.

Uredo Plucheae Sydow, Ann. Myc. **1:** 333. 1903.

Uredo biocellata Arth. Bull. Torrey Club **33:** 517. 1906.

Puccinia biocellata Vestergr. Micr. Rar. Sel. *1267.* 1908.

The teliospores of this rust have been collected on two hosts, *Pluchea fastigiata* Griseb. and *P. Quitoc* DC., in Argentina, and issued in Vestergren's exsiccati, Nos. 1267 and 1368. The rust occurs on a number of species of *Pluchea* in Florida, Guatemala and the West Indes, but no teliospores have yet been found in North America.

Uredo nominata sp. nov.

II. Uredinia amphigenous, grouped upon discolored areas, 5–10 mm. across, oblong or linear, 0.4–5 mm. long, somewhat

tardily naked, pulverulent, light-brown, ruptured epidermis evident; urediniospores ellipsoid or obovoid, 18–23 by 23–32 μ; wall light cinnamon-brown, 1.5–2 μ thick, moderately echinulate, the pores 3 or 4, approximately equatorial.

On *Sisyrinchium Bermudianum* L. (*Iridaceae*), St. Davids, Bermuda, February 26—March 9, 1908, *Stewardson Brown 611*. A number of rusts have been described on *Sisyrinchium*, both from North and South America, but representatives of them are rare and scanty in herbaria. Judging from descriptions and the small amount of material available this form should be considered distinct.

Uredo cumula sp. nov.

II. Uredinia amphigenous, somewhat aggregate or scattered, round, applanate, small, 0.1–0.4 mm. across, soon naked, pulverulent, cinnamon-brown, conspicuous, ruptured epidermis noticeable; urediniospores broadly ellipsoid or obovate, small, 18–20 by 22–25 μ; wall pale cinnamon-brown, thin, 1 μ or less, finely echinulate, the pores 2, equatorial, indistinct.

On *Buchnera elongata* Sw. (*Scrophulariaceae*), Herradura, Cuba, March 24, 1921, *John R. Johnston 2530*. The species is notable for its small delicate spores, although when massed on the surface of the plant they are of ordinary conspicuousness. The generic name of the host is sometimes written *Buechnera*.

Uredo curvata sp. nov.

II. Uredinia hypophyllous, loosely grouped on slightly discolored areas 3–5 mm. across, round, small, 0.1–0.3 mm. in diameter, soon naked, pulverulent, dark chestnut-brown, ruptured epidermis inconspicuous; paraphyses numerous, peripheral, incurved, hyphoid or somewhat clavate, slender, about 7 by 30 μ, the wall thin, less than 1 μ, slightly thicker above, 1–2 μ, colorless below, light chestnut-brown above, sometimes one- or two-septate; urediniospores obovate, 14–16 by 26–32 μ, very strongly curved; wall chestnut-brown, uniformly thin, 1 μ, with one indistinct pore on the concave side below the equator, evenly echinulate-verrucose.

On *Inga vera* Willd. (*Mimosaceae*), San Diego de los Baños, Cuba, March 26, 1921, *John R. Johnston 2540*. The species is remarkable for its very much curved spores with one pore on the indented side, being in this respect similar to the uredinia of *Puccinia invaginata* Arth., which occurs in Cuba on the rhamnaceous genus *Gouania*.

Aecidium Yuccae sp. nov.

O. Pycnia amphigenous, in small and crowded groups, inconspicuous, honey-yellow, subepidermal, small, globoid,

80–115 μ in diameter; ostiolar filaments prominent, 45–65 μ long, agglutinated into a column.

I. Aecia amphigenous, irregularly arranged in loose groups, cylindric, 0.3–0.5 mm. in diameter and somewhat higher; peridium firm, erect, the margin finely erose; peridial cells angularly globoid or ellipsoid in face view, rectangular or somewhat rhomboidal in section, 16–18 by 23–35 μ, abutted or slightly overlapping, the outer wall 3–5 μ thick, smooth, the inner wall thinner, about 2 μ, finely verrucose; aeciospores globoid or broadly ellipsoid, 16–20 by 19–24 μ; wall colorless, thin, 1 μ or less, very closely and finely verrucose.

On *Yucca glauca* Nutt. (*Dracaenaceae*), Crawford, Nebraska, June 28, 1921, *A. O. Garrett.* An interesting species, as it comes from the semi-arid, sandhill region, where a number of grass rusts of restricted range occur, to one of which it undoubtedly is genetically connected. Only a few groups of aecia on the upper part of a young leaf were secured by Mr. Garrett, who kindly submitted all the material for study.

PURDUE UNIVERSITY,
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Studies in the genus Lupinus—VII. L. succulentus and L. niveus.

CHARLES PIPER SMITH

(WITH FOUR TEXT FIGURES)

INTRODUCTION

In accounting for the North American annuals and biennials of the subgenus *Lupinus*, I have found it advisable to recognize six groups, as indicated and contrasted in the key below. These groups, however, do not provide for the Mexican annuals, *L. bilineatus* Benth., *L. Hartwegi* Lindl., and *L. Barkeri* Lindl., nor for the Costa Rican *L. Clarkei* Oersted, as satisfactory material of these species has not been available for my study.

Keel petals ciliate on their lower edges near the claw, commonly ciliate above, also, near the claw.
- Racemes shorter than their peduncles. — STIVERSIANI.
- Racemes longer than their peduncles.
  - Flowers verticillate; leaflets glabrous above. — SUCCULENTI.
  - Flowers scattered; leaflets more or less hairy above. — SPARSIFLORI.

Keel petals non-ciliate on their lower edges.
- Keel petals ciliate above near the point. — MICRANTHI.
- Keel petals non-ciliate on both upper and lower edges.
  - Flowers verticillate; leaflets hairy above. — MICRANTHI.
  - Flowers with scattered
    - Leaflets hairy above, 2-5 mm. wide; pods 10-15 mm. long; seeds 1.5-3 mm. long. — CONCINNI.
    - Leaflets glabrous above, 6-12 mm. wide; pods 30-50 mm. long; seeds 4-6 mm. long. — SUBCARNOSI.

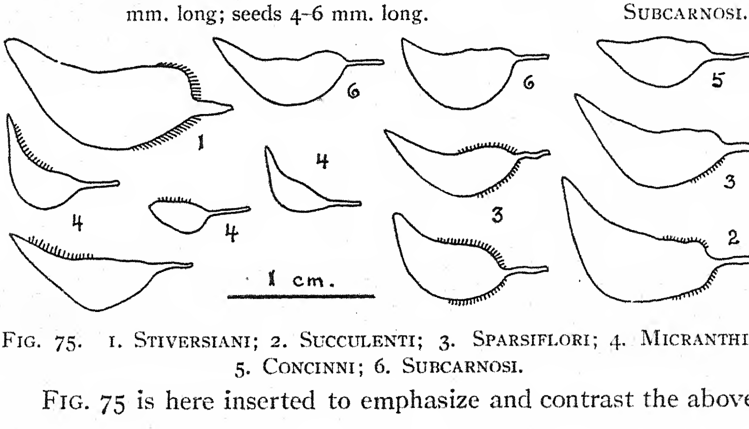

FIG. 75. 1. STIVERSIANI; 2. SUCCULENTI; 3. SPARSIFLORI; 4. MICRANTHI; 5. CONCINNI; 6. SUBCARNOSI.

FIG. 75 is here inserted to emphasize and contrast the above

indicated variations in the keel. Four of these groups, namely, the *Sparsiflori*, *Stiversiani*, *Concinni*, and *Subcarnosi*, have been treated in the last two papers of this series (Bull. Torrey Club **47**: 487-509. 1920; **48**: 219-234. 1921). This paper will consider the *Succulenti* and one species of the *Micranthi*.

SUCCULENTI

The one species included here is so distinct from all the other annuals of our region that I do not feel justified in placing it in any of the other groups recognized. The ciliation of the keel is too constant to be ignored, though nowhere properly described. This is the group some years ago indicated by me under the name *Affines* (Muhlenbergia **6**: 134. 1911).

1a. LUPINUS SUCCULENTUS Dougl.; C. Koch, Wochenschrift Gaertn. Pflanzenkunde **4**: 277. 1861. [FIG. 76.]

Stout, succulent or fistulous, 2-6 dm. tall, branched, nearly glabrous or sparsely appressed-pubescent (rarely villous): leaves several; petioles slender, 6-12 cm. long, one to three times as long as their leaflets, stipules linear-setaceous, 10-12 mm. long, the free part widely divergent; leaflets seven to nine, cuneate or cuneate-obovate, rounded, truncate, or emarginate at apex, usually apiculate, glabrous above, sparsely appressed-pubescent beneath, 20-70 mm. long, 6-16 mm. wide; peduncles 2-8 cm. long, racemes 6-30 cm. long, flowers subverticillate in about four to eight whorls or groups, spreading in anthesis, becoming ascending upon withering, 12-17 mm. long; bracts early deciduous, linear, 6-10 mm. long; pedicels spreading-pubescent with very short hairs, 4-6 mm. long; calyx bracteolate, subappressed-pubescent, the upper lip deeply two-toothed or bifid, about 5 mm. long, the lower lip lanceolate, entire and acute or three-toothed, 7-8 mm. long; banner suborbicular, about 14 x 13 mm. including the claw, glabrous, blue with yellow center turning violet, or rarely bluish white, wings 12-14 mm. long, about 8 mm. wide, blue or rarely nearly white, more or less ciliate at the base above the claw, keel stout, 12-14 mm. long, the point upturned, distinctly ciliate near the claw both above and below, purple-tipped or orange-tipped in the albinos, otherwise whitish; pods about 50 mm. long, 9-10 mm. wide, loosely pubescent or villous with hairs 0.5 to 1.5 mm. long, ovules eight to ten; seeds oblong, 3.5-5 mm. long, much marbled with dark brown, with a pair of contiguous whitish spots embracing the raphe, the hilum deeply sunken in a protruding ring: axial root normally vertical.

This is the plant that has been known as *L. affinis* Agardh, since Watson reviewed the genus in 1873 (Proc. Am. Acad. **8**: 517), but the specimens so marked in the Lindley Herbarium

(now at Cambridge University, England) are not this species. Indeed, Dr. Greene, in 1891 (Flora Franciscana 1:40), expressed doubt that our robust, succulent annual is the true *L. affinis*, and I have long felt that Agardh's description does not satisfactorily apply to same. It remained, however, for Miss Alice Eastwood to unearth the needed evidence, and her photograph of Lindley's specimen labelled *L. succulentus* shows said specimen to be of this species. Likewise, her photographs of the specimens labelled *L. affinis* Agardh show equally well that same should not be referred to this robust species, but rather to *L. nanus*, a species which will be treated in a later paper. These are the conclusions arrived at by Miss Eastwood with the specimens before her.

Koch knew the species as a garden plant under the name *L. succulentus* and quotes Biedenfeld's Garten Jahrbuch as his

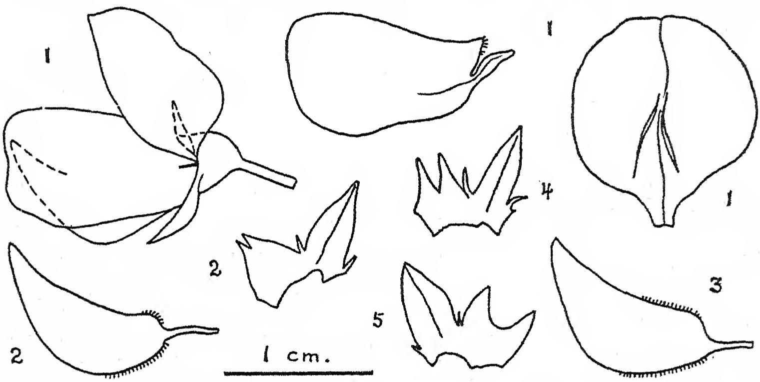

FIG. 76. LUPINUS SUCCULENTUS Dougl. 1. *C. P. Smith 1406* (CPS); 2. *K. Brandegee* (UC 81964); 3. *Edna Hannibal* (DS 87569); 4. *L. R. Abrams 4224* (DS); 5. *K. Brandegee* (UC 187796).

only authority for attributing the name to Douglas. He also states that the same species was distributed from Darmstadt as *L. Liebmanni* and from Geneva as *L. purpureus* Del. Considering the species to be undescribed, he drew up in 1861 a description in German, accrediting the species to Douglas and suggesting that its native home must be assumed to be California or Oregon. As his description is not readily available in this country, it is reproduced here:

Die ganze, mehr neidrig bleibende Pflanze ist mit Ausnahme der Oberfläche der Blätter sehr fein behaart; 9 länglichkeilförmige Blättchen mit zurückgebogener Spitze; Nebenblättchen wenig angewachsen, borsten-

förmig, aufrecht; Aehre gestielt, kurz, aus wenigen (meist nur 3) Quirlen bestehend; Deckblätter länger als die Knospen; Deckblättchen klein und oft undeutlich; Oberlippe 2 theilig, kürzer als die ganze Unterlippe; Schiffchen an der Basis des Randes gewimpert.

Diese durch ihre dunkelen, schwarzvioletten Blüthen ausgezeichnete und sehr zu empfehlende Art scheint noch gar nicht beschrieben zu sein. Obwohl Douglas als Autor angegeben ist und man vermuthen muss, dass Kalifornien oder das Oregon-Gebiet Vaterland sind, so haben wir den Namen doch nur in Biedenfeld's Garten Jahrbuche (im 1. Hefte S. 292) gefunden. Aus welcher Zeitschrift der Verfasser die Pflanze entlehnte, wissen wir nicht. Neuerdings ist sie weider aus dem Darmstädter botanischen Garten als L. Liebmanni, aus dem Genfer als L. purpureus Del. verbrietet worden. Wir vermuthen, dass die Namen in dem Verzeichnisse irgend eines botanischen Gartens aufgestellt wurden.

Koch also here recorded his opinion that the species seems to be related to *L. arvensis* Benth. and to *L. ramosissimus* Benth., a Colombian species collected by Hartweg, and especially to the plant illustrated in plate eleven of the Botanical Register for 1847 and there named *L. Ehrenbergii.* Evidently some one claimed this species to be the same as *L. densiflorus* Benth.; for Koch, in 1867 (Ind. Sem. Hort. Berol., App. 1: 11), published a Latin diagnosis and stated that it differed from *L. densiflorus* in its fragile stems and branches and violet flowers. Since this description is likewise difficult of access, I reproduce most of it here:

Annuus, humilis, ramosus, fragilis, puberulus; stipulae setiformes, erectae, paululum adnatae; folia 9-foliolata, 3-pollicaris; petiolus longitudine folia aequans; . . . foliolis supra glaberrimus subtus puberulis oblongis, sed ad basin magis attenuatis, apice breviter cuspidato, recurvo; . . . spica verticillata, verticillis distantibus; . . . labium superius bifidum, inferius lanceolatum, integrum; . . . vexillum et alae violaceae, . . . carina albida, ad partem superiorem violacea, apice flavescente; legumen pilosum, inter semina constrictum.

Species per longum tam tempus in hortis culta e California nec non e terris mexicanis sine dubio allata, accredit ad *L. densiflorus* Benth., differt tamen fragilitate caulis ramosumque et floribus violaceis. Nusquam descripta esse videtur, sed nupperime iterum in hortis botanicis nominibus: Lupini Liebmannii et purpurei occurrit.

There is a sheet of this species, marked "*Lupinus succulentus* Douglas, 1843", in a large old collection of European garden plants recently secured by Stanford University. Thus, I consider it advisable to accept this name for this species, which otherwise is without a proper botanical name. Douglas could hardly have overlooked the species during his sojourn in California, and certainly a more appropriate name could not be found. I cannot

follow Watson (Proc. Am. Acad. **8:** 538. 1873; and Bib. Index 236. 1878) in assuming that this "is probably but a garden form" of *L. densiflorus*, nor accept his application of Agardh's name to this species. Koch might have said more about the pods and seeds, but his "legumen . . . inter semina constrictum" and his comparison of the species with *L. arvensis. L. ramosissimus*, and *L. Ehrenbergii* do not point to a confusion with *L. densiflorus.*

The species is so common in the San Francisco Bay region that I will omit citation of many specimens examined. An albino form (petals pale bluish white) was common in 1921, in and near the mouth of Alum Rock Canyon, Santa Clara County. This was mostly in pure patches, but sometimes associated with pale blue, or the normal, dark blue, form. Seeds were secured from marked colonies, but those from the palest-flowered plants were heavily pigmented, perhaps averaging even darker, rather than paler, than is normal for the species.

CALIFORNIA. Alameda County: Berkeley, Feb., 1899, *H. P. Chandler 239* (UC); Livermore, April, 1904, *A. A. Heller 7320* (B, UC); Niles, June, 1918, *H. A. Walker 5006* (UC); Sunol Valley, June, 1916, *L. R. Abrams 5699* (DS). Butte County: Chico, *A. A. Heller 12983* (UCX). Colusa County: College City, 1905, *Alice King* (UC); Sycamore Slough, Sacramento River, April, 1917, *R. S. Ferris 621* (DS). Contra Costa County: Brentwood, May, 1893, *A. Eastwood* (CA); Bryon Springs, March, 1914, *A. Eastwood* (CA); Concord, March, 1914, *A. Eastwood* (CA); Martinez, April, 1862, *W. H. Brewer 996* (UC). Fresno County: Alcalde, March, 1892, *T. S. Brandegee* (CA); Alcalde, March, 1893, *A. Eastwood* (CA); Huron, March, 1893, *A. Eastwood* (CA). Kern County: Sunset Oil Wells, March, 1893, *A. Eastwood* (CA). Los Angeles County: Avalon, Santa Catalina Island, May, 1920, *G. L. Moxley 732* (CPS); Claremont, April, 1904, *C. F. Baker* (CA); Elysian Hills, Feb., 1903, E. Braunton (UC); Los Angeles, April, 1901, *E. D. Palmer* (UC); Redondo, San Pedro Hills, March, 1903, *L. R. Abrams 3141* (DS); Santa Catalina Island, May, 1916, *K. Brandegee* (UC). Monterey County: Carmel-by-the-Sea, March, 1910, *Alice D. Randall* (DS); Castroville, *T. S. Brandegee* (CA); Jolon Grade from King City, April, 1920, *C. D. Duncan 78* (DS); Pacific Grove, Pebble Beach, April, 1909, *L. R. Abrams 4224* (DS); Posts, June, 1893, *A. Eastwood* (CA). Riverside County:

Hemet, May, 1904, *C. F. Baker 4189* (UC, DS). Sacramento County: Sacramento, April and May, *Edna Hannibal* (DS). San Benito County: Idria, May, 1893, *A. Eastwood* (CA); San Benito, May, 1918, *A. Eastwood* (CA). San Bernardino County: San Bernardino, April, 1888, *S. B. & W. F. Parish* (UC), and March, 1901, *S. B. Parish* (DS). San Diego County: Campo, April, 1920, *A. Eastwood* (CA); La Jolla, April, 1903, *T. S. Brandegee* (UC), and March, 1914, *F. E. & E. S. Clements* (UC); Linda Vista, May, 1894, *T. S. Brandegee* (UC); Point Loma, April, 1913, *A. Eastwood* (CA); San Diego, June, 1885, *Fanny E. Fish* (UC), and March, 1889, *C. R. Orcutt* (CA), also April, 1905, *K. Brandegee* (DS, UC). San Francisco County: Twin Peaks trail, April, 1921, *Bertha Dold 105* (CPS). San Joaquin County: Tracy, April, 1903, *C. F. Baker 2908* (CA). San Luis Obispo County: San Luis Obispo, May, 1882, *M. E. Jones* (CA), April, 1886, *M. Miles* (CA), July, 1911, *K. Brandegee* (UC), and June, 1914, *C. P. Smith 2851* (CPS); San Luis Valley, March, 1882, *Mrs. R. W. Summers* (UC). San Mateo County: Crystal Springs Lake, April, 1896, *A. Eastwood* (UC); Portola, May, 1903, *A. D. E. Elmer 4827* (CA, DS); La Honda summit, May, 1900, *W. R. Dudley* (DS); San Mateo ravine, April, 1894, *W. R. Dudley* (DS); San Pedro, June, 1903, *A. D. E. Elmer 4681* (CA, DS). Santa Barbara County: Ellwood, May, 1908, *A. Eastwood 2* (CA); Santa Cruz Island, April, 1888, *T. S. Brandegee* (UC), July-Aug., 1886, *E. L. Greene* (CA), and June, 1918, *A. Eastwood* (CA); Santa Maria River, June-July, 1906, *A. Eastwood 329* (CA). Santa Clara County: Alum Rock Park, April, 1907, *A. A. Heller 8471* (CPS, DS), Feb., 1921, *C. P. Smith 3212*, albino, and *3213*, normal colored (CPS); Loma Prieta, April, 1894, *J. B. Davy 631* (UC); Los Altos, April, 1894, *W. R. Dudley* (DS); Saratoga, June, 1915, *L. R. Abrams 5260* (DS); Stanford University, April, 1903, *A. D. E. Elmer 4920* (CA, DS), and May, 1902, *C. F. Baker 858* (CA, UC); Campbell, March, 1921, *Claribel Boesch 101* (CPS); Evergreen, March, 1921, *Lotta Bland 101* (CPS); Madrone Packwood School, April, 1921, *Mrs. A. F. Cochrane 102* (CPS). Santa Cruz County: Chittenden, April, 1921, *C. P. Smith 3259* (CPS); Ellicott, June, 1908, *C. P. Smith 1455* (CPS). Shasta County: Anderson, April, 1914, *L. E. Smith 139* (CA). Solano County: Cordelia, April, 1902, *Heller & Brown 5369* (B, DS); Vacaville, May, 1891, *W. L. Jepson* (DS), and May, 1903, *C. F. Baker 5071* (DS, UC). Sonoma

County: Petaluma Valley, April, 1908, *C. P. Smith 1382* (CPS). Sutter County: Marysville Buttes, April, 1915, *A. A. Heller 11,792* (CA, DS, UCX); West Butte, April, 1917, *R. S. Ferris 690* (DS); Yuba City, April, 1891, *W. L. Jepson* (UC). Tehama County: Red Bluff, May, 1914, *L. E. Smith 670* (CA). Ventura County: Ojai Valley, April, 1896, *F. W. Hubby 41* (UC). Yolo County: Davis, April, 1915, *P. B. Kennedy 21* (UCX); Yolo, June, 1914, *C. P. Smith*, seed only (CPS).

LOWER CALIFORNIA. Carysito, April, 1885, *C. R. Orcutt* (CA).

ARIZONA. Gila County: Roosevelt Dam, April 1917, *A. Eastwood 6286* (CA), and May, 1919, *A. Eastwood* (CA).

The distribution of this plant is thus seen to be from Shasta County to northern Lower California, the occurrence at Roosevelt Dam, Arizona, being certainly due to a casual introduction of seed from California. Variations are not particularly well-marked, except in two cases, as indicated below:

1b. **Lupinus succulentus Layneae** var. nov.

Humilis ramis decumbentibus, villosus pilis pandentibus 2 mm. longis, leguminibus aeque villosis.

Depressed, 1 dm. tall, with decumbent branches and short racemes, densely villous with hairs 2 mm. long even on the pods.

CALIFORNIA. San Mateo County: Farallon City, June, 1918, *K. Brandegee* (TYPE, UC 187796).

Mrs. Brandegee's maiden name was Mary Katharine Layne.

1c. **Lupinus succulentus Brandegeei** var. nov. [FIG. 77.]

Humilis, erectus, foliolis maximis prope 20 mm. longis; floribus 9–10 mm. longis, vexillo 10 mm. longo, 7.5 mm. lato, alis apice non truncatis, carina ad basin super paulum ciliata.

Much reduced in stature and size of flowers; about 1 dm. tall, largest leaflets about 20 mm. long, flowers 9–10 mm. long, banner about 10 x 7.5 mm., wings not truncate at the apex, keel less ciliate above.

LOWER CALIFORNIA. Comondu, Feb., 1889, *T. S. Brandegee*

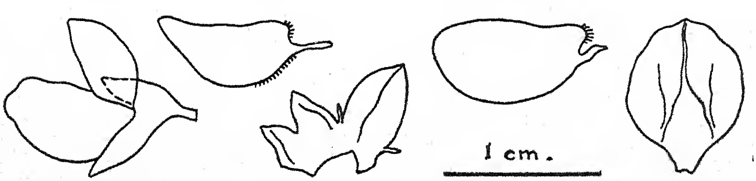

FIG. 77. LUPINUS SUCCULENTUS BRANDEGEEI C. P. Smith. *T. S. Brandegee* (UC 83498).

(TYPE, UC 83498); San Julio, April, 1889, *T. S. Brandegee* (UC), and April, 1919, *T. S. Brandegee* (CA).

MICRANTHI

L. micranthus and its nearest relatives comprise the largest and most difficult group of the annual species of the subgenus *Lupinus* Watson. Variations in shape and size of flowers, leaflets, pods, and seeds produce conspicuous extremes which have suggested "new species" not a few in number. That botanists have appreciated these variations is evidenced by the following list of published names:

L. bicolor Lindl. Bot. Reg. **13**: *pl. 1109*. 1827.
L. micranthus Dougl.; Lindl. Bot. Reg. **15**: *pl. 1251*. 1829.
L. nanus Dougl.; Benth. Tran. Hort. Soc. II. **1**: 409. 1835.
L. affinis Agardh, Syn. Gen. Lup. 20. 1835.
L. Aschenbornii S. Schauer, Linnaea **20**: 739. 1847.
L. micranthus microphyllus Wats. Proc. Am. Acad. **8**: 535. 1873.
L. niveus Wats. *ibid.* **11**: 126. 1876.
L. trifidus Torr.; Wats. *ibid.* **12**: 250. 1877.
L. chihuahuensis Wats. *ibid.* **21**: 423. 1886.
L. carnosulus Greene, Bull. Cal. Acad. **2**: 144. 1886.
L. umbellatus Greene, *ibid.* **2**: 145. 1886.
L. pachylobus Greene, Pittonia **1**: 65. 1887.
L. polycarpus Greene, *ibid.* **2**: 171. 1888.
L. rostratus Eastwood, Proc. Cal. Acad. II. **6**: 424. *pl. 56*. 1896.
L. persistens Heller, Muhlenbergia **2**: 62. 1905.
L. vallicola Heller, *ibid.* **4**: 40. 1908.
L. apricus Greene, Leaflets **2**: 67. 1910.
L. vallicola apricus C. P. Smith, Muhlenbergia **6**: 135. 1911.
L. hirsutulus Greene, Leaflets **2**: 152. 1911.
L. sabulosus Heller, Muhlenbergia **7**: 9. 1911.
L. Pipersmithii Heller, *ibid.* **7**: 93. 1911.
L. strigulosus Gandoger. Bull. Soc. Bot. France **60**: 461. 1913.

In addition to accounting for these published names, the scope of these papers will necessitate disposing of some seven herbarium names. Of the above, only one species will be treated at this time, the remainder being scheduled for attention in subsequent papers.

The name *Bicolores* would have been a more appropriate appellation for this group; but the name here employed has been in use for some time. The flowers measure 6–16 mm. in length and are always bicolored but are certainly not always small. They are usually verticillate; but the racemes are sometimes reduced to one umbel-like whorl, and in one form the flowers are strictly scattered. The keel is normally ciliate on the upper

margin near the point, a character not shared by any other group of North American annual lupines; however, two of the forms lack this ciliation. The upper surface of the leaves is almost always with at least a few short hairs.

2. LUPINUS NIVEUS Wats. Proc. Am. Acad. **11**: 126. 1876. [FIG. 78.]

Apparently annual or biennial with persistent petioled cotyledons, erect, 3-4 dm. tall, branched well above the base, densely velvety tomentose above the cotyledons, which are fleshy, glabrous, the blades about 20 mm. long, 12 mm. wide: leaves velvety on both sides, petioles 6-8 cm. long, leaflets eight or nine, rounded or angled at the apex, 30-40 mm. long, 9-12 mm. wide: peduncles 5-8 cm. long, racemes 8-12 cm. long, loosely few-flowered, bracts deciduous, linear, 5-8 mm. long; flowers 10 mm. long, spreading or subdrooping, pedicels 4-6 mm. long; calyx practically ebracteolate, the lips equal in length, about 5 mm. long, the upper cleft or bifid, over 4 mm. wide, the lower bluntly two-toothed, barely 3 mm. wide. petals broad, deep blue, banner suborbicular, about 10 x 10 mm., greenish

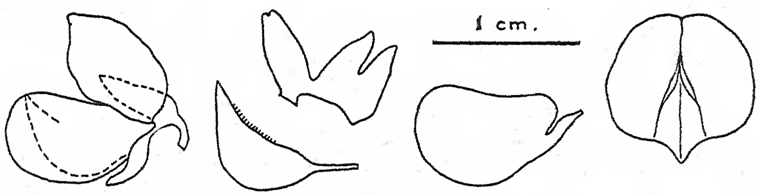

FIG. 78. LUPINUS NIVEUS Wats. *E. Palmer 861* (G, US).

yellow in the center, wings about 10 x 7 mm., only slightly ciliate on the upper margin near the very sharp upturned point; pods yellow, 40-50 mm. long, 8-10 mm. wide, stout, ovules four or five; seeds pale, obscurely spotted, mostly 5-6 mm. long.

This is a very distinct, isolated, insular species not closely related to any other known species; but as I see it, better lined up with *L. nanus*, at least for the present. For a long time I was misled by Watson's clause, "allied to *L. leucophyllus*", and thus had difficulty in classifying this plant.

LOWER CALIFORNIA: Guadelupe Island, 1875, *E. Palmer 25*. (G); 1889, *E. Palmer 861* (G, US); 1893, *F. Franceschi* (US).

My thanks are especially due to Miss Alice Eastwood for the use of unpublished notes and to Dr. J. H. Barnhart for important bibliographical help.

The abbreviations used herein in the citation of specimens may be identified by reference to the following list:

B, Brooklyn Botanic Garden;
CA, California Academy of Science;
CPS, private herbarium of the writer;
DS, Dudley Herbarium, Stanford University;
G, Gray Herbarium, Harvard University;
UC, Department of Botany, University of California;
UCX, Division of Agronomy, University of California Experiment Station;
US, United States National Herbarium.

SAN JOSE, CALIFORNIA

A new American fossil hepatic

Marshall A. Howe and Arthur Hollick

(with one text figure)

Fossil Hepaticae are among the rarest of known paleobotanical remains. The total number of described species is less than twenty. Of these more than half are identifiable as living species of Jungermanniaceae, all but one of which are represented merely by fragments enclosed in amber of recent geologic age, found in the Old World. The remainder probably all belong in the Marchantiaceae.

Three species only have been heretofore recorded from America,* all of which are referable, either definitely or provisionally, to the latter family. It should be remarked, however, that the identity, as well as the botanical relationship of the species last cited, in our footnote, is questioned by Fontaine, who says (*l. c.*, p. 54): "It is similar to that of a *Brachyphyllum* and the plant may be really a twig of that conifer." Incidently it may also be remarked that this is the only species recorded for any geological horizon older than Tertiary, and that the type of the species, from the Jurassic of England, was originally described as an alga under the name *Fucoides erectus* Bean.†

Several years ago a collection of fossil plant remains from Florissant, Colorado, was sent by Mr. T. D. A. Cockerell to the New York Botanical Garden for examination. Among them was what appeared to be a fragment of a bryophyte; but it was so small and imperfectly defined that it was not identified, even as to its probable class relationship, until an enlarged photograph (Fig .1) was made. The specimen evidently represents a

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*(a) *Preissites Wardii* Knowlton, Bull. Torrey Club **21**: 458. *pl. 219.* 1894. Eocene (Fort Union formation), Burn's Ranch, thirty miles from Glendive, Montana.

(b) *Marchantia Pealei* Knowlton, Proc. U. S. Nat. Mus. **35**: 157. *pl. 25.* 1908. Eocene (Lance formation), Custer County, Montana.

(c) "*Marchantites erectus* (Bean) Seward?", *fide* Fontaine in Ward, Monog. U. S. Geol. Survey **48**: 53. *pl. 6, f. 1, 2.* 1905. Jurassic, Douglas County, Oregon.

†In Leckenby, Quart. Jour. Geol. Soc. London **20**: 81. *pl. 11, f. 3a, 3b* (erroneously numbered *2a, 2b* on the plate). 1864.

member of the Bryophyta and probably belongs to the family Jungermanniaceae of the class Hepaticae.

Jungermanniopsis gen. nov.

Plants slender and minute, consisting of stem and leaves and showing a pronounced dorsiventrality, with ventral (postical) roothairs and dorsal (antical) apparently one-ranked but probably two-ranked ovate-acuminate, often subfalcate, assurgent or subvertical (antically secund) leaves and with occasional indistinct suggestions of much smaller lateral lanceolate or ligulate leaves.

Jungermanniopsis Cockerellii sp. nov.

Stem ascending at apex; leaves 1–1.5 mm. long, 0.4–0.7 mm. in maximum width, contiguous, narrowly spaced, or slightly overlapping at extreme base, the intervals between the leaves commonly resembling the outlines of inverted leaves, the often subfalcate acuminations directed forwards, the acuminations sometimes accentuated by reflexions of the subapical margins, the margins entire or with indistinct indications of small teeth.

COLLECTOR: T. D. A. Cockerell.

FORMATION AND LOCALITY: Miocene shale, Florissant, Colorado (Station 14).

Type specimen in the Museum of the New York Botanical Garden.

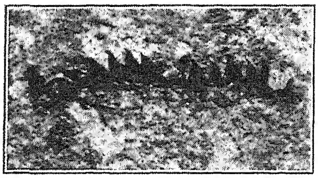

FIG. 1. JUNGERMANNIOPSIS COCKERELLII Howe & Hollick

The one fragment, upon which the genus and species are based, is about 12 or 13 mm. long and evidently lies on its side. The specimen shows a possible forking of the stem near the apex, with one branch ascending and the other descending, but the descending part is probably only a collection of roothairs. Among the living Hepaticae, the pointed, antically secund leaves of *Jungermanniopsis* suggest the widely distributed *Herberta adunca* (Dicks.) S. F. Gray; but there is no indication that the leaves are bilobed as in the genus *Herberta*. In its antically secund leaves, it resembles also such leafy Hepaticae as *Jamesoniella autumnalis* (DC.) Steph. and certain species of *Nardia*, but in the form and looser disposition of the leaves it is very different from any of these. The possible presence of smaller

ligulate or lanceolate lateral leaves might, if fully substantiated, result in placing the plant with the Musci rather than with the Hepaticae. But the small size and general habit of the organism suggest affinities with the Jungermanniaceae rather than with the Musci. The specific name is in honor of Mr. T. D. A. Cockerell, the collector.

A new genus of fossil Liliaceae

T. D. A. Cockerell

(WITH ONE TEXT FIGURE)

In 1873* Lesquereux reported a singular fossil from the Miocene shales of Florissant, Colorado, as *Ophioglossum Alleni*. In 1878 he figured it† and assigned it to the genus *Salvinia*, on account of its close resemblance to Heer's European fossil *S. reticulata*. Hollick‡ gave a new figure, and placed the plant in the genus *Tmesipteris*, where it remains in Knowlton's Catalogue.

This so-called *Tmesipteris Alleni* is common in the Florissant shales but has remained an unsolved problem. A number of years ago, at the British Museum, I showed specimens to Dr. A. C. Seward and Dr. A. G. Nathorst. We could all agree that there was no relationship with *Tmesipteris*, but it was impossible to even guess at the true position of the species. Seward,§ when publishing on the subject later, rejected the reference to *Tmesipteris*, without being able to suggest another alternative. In 1913,¶ to avoid perpetuating an obvious error, I referred the plant to *Carpolithes*, supposing it to represent some sort of fruiting body. No seeds could ever be seen, although the appearance suggested a flattened pod; but the published figures failed to show a thickening on the midrib, a little beyond the middle. In a very good specimen found at Florissant in November, 1921, there is a definite body at this point, with a diameter of nearly 3 mm. It looks like a small berry, with the contents extruded (FIG. 1, C).

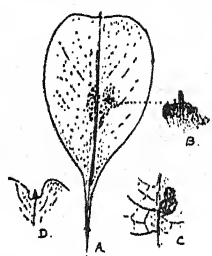

FIG. 1. BRACHYRUSCUS ALLENI Cockerell
A. Cladode bearing pistillate flower. B. flower, enlarged. C. Fruit on a mature cladode. D. Emarginate apex of a mature cladode.

Probably the riddle would never have been solved but for the discovery of a younger specimen in the Florissant shales,

* For bibliographical references see Knowlton, Mesozoic and Cenozoic plants of North America. U. S. Geological Survey Bull. 696: 626. 1909.

† Tertiary Flora, *pl. 5, f. 11.* 1878.

‡ Bull. Torrey Club. **21**: *pl. 205, f. 12.* 1894.

§ Fossil plants **2**: 25. 1910.

¶ Am. Jour. Sci. VI. **36**: 500.

at Station 14. This (FIG. 1, A, B) shows that we have to do neither with a leaf, frond nor pod, but with a cladode. Attached to the midrib is an indistinct mass, presumably a thin bract, upon which can be seen a dark object (FIG. 1, B), which seems to agree very closely with the flower of *Ruscus*. The pistil is erect and distinct. The plant is dioecious, and the staminate flower is as yet unknown. At first I thought there might be two flowers, but the supposed second one is, I believe, part of the midrib.

As I could not identify the plant with *Ruscus*, I consulted Dr. Britton, who very kindly sent me material of *Phyllonoma ruscifolia* Willd. and *Ruscus hypoglossum* L. It was at once apparent that the fossil had nothing to do with *Phyllonoma*, but returning to *Ruscus* as the only alternative, I was able to recognize close morphological similarity. The genus *Ruscus* is today limited to a few Palaearctic species, with lanceolate to ovate sharply pointed cladodes. The apical points are stiff and sharp, as any one who has handled butcher's broom will testify. At first sight the venation seems quite different from that of the fossil, but if we imagine the *Ruscus* cladode broadened and abbreviated until the principal veins are nearly or quite transverse instead of longitudinal, the correspondence is exact. The published figures of the fossil do not show that there are principal veins, just as in *Ruscus*.

The morphological correspondence is so exact that it becomes a question whether the fossil can be referred to *Ruscus*. However, considering the broad form of the cladodes, with truncate or emarginate, mucronate apex, the essentially transverse veins, and the remoteness in time and space, it appears justifiable to establish a distinct genus, *Brachyruscus*, the species becoming *Brachyruscus Alleni* sp. nov.* Whether Heer's *Salvinia ret-*

* Dr. Hollick writes that he is not convinced that the flowering cladode, which I have figured and described, belongs to the same plant as the "*Tmesipteris*" *Alleni*. I had considered the possibility of there being two different things, and am personally entirely convinced that all the specimens belong to a single species. However, I will designate the flowering specimen as the type of the genus and of a species which I will name *B. Alleni*. This name will remain valid if my view is correct, only *B. Alleni* Cockerell will be a synonym of *B. Alleni* (Lesq.) Cockerell. If it should be decided that there are two quite different plants, *B. Alleni* Cockerell will still stand, only to fall in case some author considers that two distinct species of *Brachyruscus* are present.

iculata is congeneric, it is impossible to say; the reticulation, as figured, looks different.

Ruscus today has its western limit in Madeira. The insular form, which I saw in cultivation in Funchal, is regarded as a race of *R. hypophyllum* L., but is perhaps specifically distinct. The name *R. latifolius* Lowe is preoccupied by Rafinesque.

BRACHYRUSCUS gen. nov.

Cladodes pyriform to suboval in outline, with a strong midrib; apex obtuse, emarginate, with a stiff mucro representing the end of the midrib or morphological apex; principal veins diverging from the midrib approximately at right angles, except toward the apex, where they form angles of about 45 degrees; principal veins connected by veinlets, forming a coarse reticulation of quadrilateral or kite-shaped areas; inflorescence borne on midrib as in *Ruscus*, with apparently a single flower, which (as imperfectly preserved) presents no characters to differentiate it from *Ruscus*. Type the following:

Brachyruscus Alleni sp. nov.

Cladode in the type specimen broad-pyriform, with tapering base, length about 18 mm. and breadth 12 mm. [in my opinion the larger cladodes (length about 31 mm. and breadth 20 mm.), with dark and distinct venation, belong to the same species]: stems unknown but doubtless woody.

INDEX TO AMERICAN BOTANICAL LITERATURE
1921

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to foresty, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Vol. 49 No. 8

BULLETIN

OF THE

TORREY BOTANICAL CLUB

AUGUST, 1922

Philippine Basidiomycetes—V*

PAUL W. GRAFF

POLYPOREAE (*Con.*)

PORIA Persoon

PORIA LEUCOPLACA (Berk.) Sacc. Syll. Fung. **6**: 322. 1888.

Polyporus leucoplacus Berk.; Hooker, Flora Nov. Zeland. **2**: 180. 1855.

LUZON: Province of Benguet, Pauai, June, 1909, *R. C. McGregor, Bur. Sci. 8720*, at an elevation of 2,100 m., on decaying timber.

Collected previously in New Zealand and Java.

TRAMETES Fries

TRAMETES ASPERA (Jungh.) Bres. Hedwigia **53**: 69. 1912.

Polyporus asper Jungh. Flor. Crypt. Javae **1**: 61. 1838.

Polystictus asper Sacc. Syll. Fung. **6**: 224. 1888.

LUZON: vicinity of Manila, August, 1912, *Sanchez 26, 27*, growing on decayed logs.

Originally described from material collected in Java.

TRAMETES INCANA Lév. Ann. Sci. Nat. Bot. III. **2**: 196. 1844.

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*The papers of this series already published have appeared as follows. Additions to the basidiomycetous flora of the Philippines. Philip. Jour. Sci: **8**: (Bot.) 299–309. *pl. 8–10.* 1913; Philippine Basidiomycetes, II. Philip Jour. Sci. **9**: (Bot.) 235–255. *pl. 2.* 1914; Philippine Basidiomycetes—III. Bull. Torrey Club **45**: 451–469. *pl. 15.* 1918; Philippine Basidiomycetes—IV. Bull. Torrey Club. **48**: 285–295. 1922.

[The BULLETIN for July (**49**: 189–222) was issued August 10, 1922.]

Polyporus incanus Lév.; Gaudichaud, Bot. Voy. Bonite **1**: 183. *pl. 137, f. 2.* 1846.

LUZON: Province of Bataan, Mount Mariveles, November, 1912, *P. W. Graff, Bur. Sci. S157, S158.*

This fungus was first collected in the Philippines by Gaudichaud-Beaupré, in 1836–37, on the visit of the corvette "La Bonite" to the port of Manila. The fungus has not been reported since, and it is with considerable pleasure that one of these three-quarter century old species is again collected.

TRAMETES PALEACEA Fr. Nov. Symb. Myc. 97. 1851.
Polyporus paleaceus Fr. Epicr. Myc. 471. 1838.

LUZON: Province of Bataan, Mount Mariveles, November 3–19, 1912, *P. W. Graff, Bur. Sci. 19098*, on a decaying log at an elevation of 400 m.
Previously reported from New Guinea.

TRAMETES CORRUGATUS (Pers.) Bres. Hedwigia **51**: 316. 1912.
Polyporus corrugatus Pers.; Gaudichaud, Bot. Voy. Uranie 172. 1826.
Polyporus fusco-badius Pers.; Gaudichaud, Bot. Voy. Uranie 172. 1826.
Polyporus scabrosus Pers.; Gaudichaud, Bot. Voy. Uranie 172. 1826.
Daedalea sanguinea Klotz. Linnaea **8**: 481. 1833.
Polyporus indecorus Jungh. Flor. Crypt. Javae **1**: 51. 1838.
Polyporus tegularis Lév. Ann. Sci. Nat. Bot. III. **5**: 131. 1846.
Hexagonia cruenta Mont. Syll. Gen. Spec. Crypt. 169. 1856.
Polystictus Persoonii Cooke, Grevillea **14**: 85. 1885.
Trametes nitida Pat. Jour. de Bot. **4**: 17. 1890.
Earliella cubensis Murr. Bull. Torrey Club **32**: 479. 1905.
Earliella corrugata Murr. Bull. Torrey Club **34**: 468. 1907.

LUZON: Province of Laguna, Mount Maquiling, February, 1912, *P. W. Graff, Bur. Sci. 16027.*

This is a much described species of universal tropical distribution. It was first described from material collected in the island of Guam and has later been reported from West Africa, India, Ceylon, Java, Borneo, Sumatra, the Philippines, Australia, and the American tropics.

DAEDALEA Persoon

DAEDALEA LURIDA Lév. Ann. Sci. Nat. Bot. III. 2: 189. 1844.

Daedalea subconfragosa Murr. Bull. Torrey Club 35: 415. 1908.

LUZON: Province of Rizal, January, 1906, *F. W. Foxworthy, Bur. Sci 22* (type of *Daedalea subconfragosa* Murr.). MINDANAO: District of Davao, Lake Laneo, Camp Keithley, July, 1907, *Mary S. Clemens "V"*.

Murrill's species, described from Philippine material, seems to be without doubt identical with that described by Léveillé from Javan specimens.

DAEDALEA PALISOTI Fr. Syst. Myc. 2: 335. 1821.

Daedalea amanitoides Beauv. Fl. Owar. 1: 44. *pl. 25*. 1804.
Daedalea repanda Pers.; Gaudichaud, Bot. Voy. Uranie 168. 1826.
Daedalea applanata Klotz. Linnaea 8: 481. 1833.
Lenzites Palisoti Fr. Epicr. Myc. 404. 1838.
Lenzites repanda Fr. Epicr. Myc. 404. 1838.
Lenzites applanata Fr. Epicr. Myc. 404. 1838.
Lenzites pallida Berk. Jour. Bot. 1: 146. 1842.
Lenzites platypoda Lév. Ann. Sci. Nat. Bot. III. 2: 180. 1844.

LUZON: Province of Rizal, Bosoboso, July, 1906, *M. Ramos, Bur. Sci. 1191*; Province of Laguna, Mount Maquiling, February, 1912, *P. W. Graff, Bur. Sci. 15951*, on fallen and decayed tree trunk. CULION: October, 1903, *Merrill 3531*. NEGROS: Gimagaan River, January, 1904, *Copeland 21*.

Daedalea indica Jungh., described from Javan material, should in all probability be added to the list of synonyms of this species. *Daedalea*, in the Polyporaceae, and *Lenzites*, in the Agaricaceae, are so closely related, and the species of one so often show a strong tendency to a variation toward the other, that considerable confusion has arisen in their determination. This is especially true in the case of this species and *D. flavida* Lév. in the Philippine material. In the latter species the variation even goes further, producing a *Trametes* form.

The types of both Léveillé's and Berkeley's species are from material collected in the Philippines. This species is of very general tropical distribution.

DAEDALEA PRUINOSA Lév. Ann. Sci. Nat. Bot. III. 2: 199. 1844.

Hexagonia glabra Lév. Ann. Sci. Nat. Bot. III. **5**: 143. 1846.

LUZON: Province of Laguna, Mount Maquiling, February, 1912, *P. W. Graff, Bur. Sci. 16015.*

Collected previously in India and the Hawaiian Islands.

Daedalea versatilis (Berk.) comb. nov.

Trametes versatilis Berk. Jour. Bot. **1**: 150. 1842.

Hexagonia ciliata Klotz. Nov. Act. Acad. Nat. Cur. **19**: (Suppl.) 235. *pl. 5, f. 1.* 1843.

Polystitictus versatilis Sacc. Syll. Fung. **6**: 244. 1888.

Funalia versatilis Murr. Bull. Torrey Club **34**: 469. 1907.

LUZON: Province of Bataan, Lamao, February, 1904, *Williams.*

As represented in Philippine material this species is of a decidedly daedaleoid type. Occasionally *Trametes*-like forms are collected, showing that it may merge into the type of plant described by Berkeley. These forms are rare, however, as also are such as might tend toward the genus *Polystictus.*

Collected in the American tropics and the Philippines.

ELMERINA Bresadola

ELMERINA CLADOPHORA (Berk.) Bres. Hedwigia **51**: 319. 1912.

Hexagonia cladophora Berk. Jour. Linn. Soc. Bot. **16**: 47. 1878.

LUZON: Province of Nueva Ecija, Cabanatuan, October, 1908, *R. C. McGregor, Bur. Sci. 5272*; Province of Rizal, Jalajala, October, 1910, *C. B. Robinson, Bur. Sci. 11925.*

Reported only from the Philippines.

ELMERINA VESPACEA (Pers.) Bres. Hedwigia **51**: 319. 1912.

Hexagonia vespacea Pers.; Gaudichaud, Bot. Voy. Uranie 170. 1826.

Lenzites aspera Klotz. Linnaea **8**: 480. 1833.

Polyporus lacerus Jungh. Flor. Crypt. Javae **1**: 65. 1838.

Daedalea inconcinna Berk. Jour. Bot. **1**: 151. 1842. Not Deless.

Lenzites platyphylla Lév. Ann. Sci. Nat. Bot. III. **2**: 179. 1844.

Daedalea aulaxina Lév. Ann. Sci. Nat. Bot. III. **2**: 197. 1844.

Hexagonia Molkenboeri Lév. Ann. Sci. Nat. Bot. III. **2**: 200 1844.

Hexagonia macrotrema Jungh.; Fries, Symb. Myc. 101. 1851.

Hexagonia albida Berk. Jour. Linn. Soc. Bot. **16**: 47. 1878.
Hexagonia Cesati Berk.; Cesati, Myc. Born. 8. 1879.
Daedalea pruinosa Ces. Myc. Born. 7. 1879. Not Léveillé.
Daedalea intermedia Berk. Jour. Linn. Soc. Bot. **18**: 385. 1879.
Lenzites nivea Cooke, Grevillea **15**: 94. 1886.

NEGROS: Province of Negros Oriental, Dumaguete, April, 1908, *Elmer 9860*.

Collected in Hawaii, Mauritius, Surinam, and Java.

HEXAGONIA Fries

HEXAGONIA APIARIA (Pers.) Fr. Epicr. Myc. 497. 1836.
Polyporus apiarius Pers.; Gaudichaud, Bot. Voy. Uranie 172. 1826.
Hexagonia Koenigii Berk. Ann. Nat. Hist. II, **10**: 379. 1853.

LUZON: Province of Bataan, November, 1909, *H. M. Curran, For. Bur. 19226*.

Collected in Java, Ceylon, and the Rawak Islands.

Hexagonia Clemensiae (Murr.) comb. nov.
Inonotus Clemensiae Murr. Bull. Torrey Club **35**: 401. 1908.
Polyporus Clemensiae Sacc. & Trott.; Saccardo, Syll. Fung. **21**: 272 1912.

MINDANAO: District of Davao, Lake Laneo, Camp Keithley, September–October, 1907, *Mary S. Clemens*, on dead wood.

Not reported as yet outside the Philippine Islands.

HEXAGONIA CUCULLATA (Mont.) Murr. Bull. Torrey Club **31**: 332. 1904.
Favolus cucullatus Mont.; Ramon de la Sagra, Hist. Phys. Polit. Nat. Cuba **9**: 378. 1841.
Favolus curtipes Berk. & Curt. Jour. Bot. Kew Gard. Miscel. **1**: 234. 1849.
Hexagonia Taxodii Murr. Bull. Torrey Club **31**: 332. 1904.

LUZON, Province of Isabella, Palanan Bay, June, 1913, *Escritor, Bur. Sci. 21185*.

Collected in Ceylon, the West Indies, tropical America, and eastern United States.

Hexagonia subrubida (Murr.) comb. nov.
Hapalopilus subrubidus Murr. Bull. Torrey Club **34**: 470. 1907.

Polyporus subrubidus Sacc. & Trott.; Saccardo, Syll. Fung. **21**: 276. 1912.

LUZON: Province of Bataan, Mount Mariveles, November, 1904, *Elmer 6912*, on dead tree branches.

This species should have been transferred to the genus *Hexagonia* by Saccardo and Trotter instead of to the genus *Polyporus*, to which it does not belong.

So far only found in the Philippine Islands.

FAVOLUS Fries

FAVOLUS MEGALOPORUS (Mont.) Bres. Hedwigia **52**: 74. 1912.

Polyporus megaloporus Mont. Ann. Sci. Nat. Bot. IV. **1**: 124. 1854.

Favolus princeps Berk. & Curt. Jour. Linn. Soc. Bot. **10**: 321. 1869.

LUZON: Province of Nueva Vizcaya, Mount Umuguen, May 19, 1909, *M. Ramos, Bur. Sci. 8282*.

Reported from French Guiana, Cuba, and Java.

FAVOLUS MULITPLEX Lév. Ann. Sci. Nat. Bot. III. **2**: 203. 1844.

LUZON: Province of Bataan, Balanja Mountains, January, 1910, *H. M. Curran, For. Bur. 19252*.

According to the collector's note this fungus is edible and used by the Negritos of Bataan Province as a food.

This species has been previously reported from Brazil and Java.

FAVOLUS SPATHULATUS (Jungh.) Lév. Ann. Sci. Nat. Bot. III, **2**: 203. 1844.

Laschia spathulata Jungh. Flor. Crypt. Javae **1**: 75. 1838.

Hymenogramme spathulata Sacc. & Cub.; Saccardo, Syll. Fung. **5**: 653. 1887.

MINDANAO: District of Davao, Mount Apo. September, 1909, *Elmer 11572*.

Previously collected in Java.

GLOEOPORUS Montagne

Gloeoporus reticulatus (Fr.) comb. nov.

Auricularia reticulata Fr. Epicr. Myc. 555. 1836.

Gloeoporus conchoides Mont.; Ramon de la Sagra, Hist. Phys. Polit. Nat. Cuba **9**: 385. *pl. 15, f. 1*, 1841.

Thelephora dolosa Lév. Ann. Sci. Nat. Bot. III. **2**: 209. 1844.

LUZON: Province of Laguna, Mount Maquiling, February, 1912, *P. W. Graff, Bur. Sci. 15952.*

Collected previously in Brazil, Cuba, and Java.

GLOEOPORUS DICHROUS (Fr.) Bres. Hedwigia **52**: 74. 1912.

Polyporus dichrous Fr. Obs. Myc. **1**: 125. 1815.

Boletus thelephoroides Hook.; Kunth, Syn. Plant. 10. 1822.

Boletus dichrous Spreng. Syst. Veget. **4**: 475. 1828.

Polyporus nigro-purpurascens Schwein. Syn. Fung. Amer. Bor. 360. 1831.

Polyporus pelleporus Secr. Mycogr. Suisse Champ. 73. 1833.

Polyporus thelephoroides Fr. Epicr. Myc. 473. 1836.

Gloeoporus candidus Speg. Fung. Guar. Pug. **1**: 30. 1883.

Polystictus thelephoroides Sacc. Syll. Fung. **4**: 284. 1886.

LUZON: Province of Rizal, January, 1906, *F. W. Foxworthy, Bur. Sci. 79.* MINDANAO: District of Davao, Mount Apo, May, 1909, *Elmer 10747.*

Collected in southern Europe, the American tropics, and Java.

LASCHIA Fries

LASCHIA MINIMA (Jungh.) Sacc. Syll. Fung. **6**: 409. 1888.

Polyporus minimus Jungh. Flor. Crypt. Javae **1**: 64. 1838.

MINDANAO: Subprovince of Butuan, March–July, 1911, *Weber 1229*, on decaying woods.

Reported previously from Java.

AGARICINEAE

PLEUROTUS Fries

PLEUROTUS FLABELLATUS Berk. & Br. Jour. Linn. Soc. Bot. **11**: 529. 1871.

LUZON: Province of Benquet, Baguio, December 5, 1910, *E. Fénix, Bur. Sci. 12948*, on dead wood.

Collected previously in tropical America, Ceylon, and South Africa.

LENTINUS Fries

LENTINUS FUSCO-PURPUREUS Kalchbr. Grevillea **8**: 153. 1880.

LUZON: Province of Rizal, Bosoboso, July, 1906, *M. Ramos, Bur. Sci. 1196.*

This species, while allied to *Lentinus Zeyheri* Berk., seems to be distinct.

Described from material collected on the Richmond River, Australia, and not previously reported from elsewhere.

LENTINUS JAVANICUS Lév. Ann. Sci. Nat. Bot. III. **5**: 118. 1846.

Lentinus Decaisneanus Lév. Ann. Sci. Nat. Bot. III. **5**: 120. 1846.

Lentinus infundibuliformis Berk. & Br. Jour. Linn. Soc. Bot. **14**: 42. 1875.

LUZON: Province of Bataan, Lamao, February 29, 1904, *Copeland 175.*

Previously reported from Java.

LENTINUS POLYCHROUS Lév. Ann. Sci. Nat. Bot. III. **2**: 175. 1844.

Lentinus praerigidus Berk. Jour. Bot. Kew Gard. Miscel. **6**: 132. 1854.

Lentinus Kurzianus Berk. & Curr. Trans. Linn. Soc. II. **1**: 120. *pl. 20, f. 2.* 1876.

LUZON: Province of Cagayan, Aparri, March, 1909, *H. M. Curran, For. Bur. 16819.*

Collected in Java, Sumatra, and eastern India.

LENTINUS SAJOR-CAJU (Rumph.) Fr. Epicr. Myc. 393. 1838.

Agaricus sajor-caju Rumph. Herb. Amb. **11**: 125, *pl. 56, fig. 1.* 1741–1755.

LUZON: Province of Bataan, Mount Mariveles, January, 1904, *Merrill 3704.*

Collected in Amboinia and Java.

LENTINUS TANGHINIAE Lév. Ann. Sci. Nat. Bot. III. **5**: 119. 1846.

MINDANAO: District of Davao, Todaya, March, 1904, *Copeland 516.*

Described from material collected in Madagascar.

LENTINUS VELUTINUS Fr. Linnaea **5**: 510. 1830.

Scleroma velutinum Fr. Epicr. Myc. 392. 1838.

Lentinus setiger Lév. Ann. Sci. Nat. Bot. III. **2**: 176. 1844.

Lentinus brachatus Lév.; Zollinger, Syst. Verz. Ind. Arch. 17. 1854.

MINDANAO: District of Davao, Todaya, April, 1904, *Copeland.* Collected previously in Brazil, Cuba, and Guiana.

LENZITES Fries

LENZITES ACUTA Berk. Jour. Bot. **1**: 146. 1842.

LUZON: Province of Cagayan, March, 1909, *Becani, For. Bur. 16712.*

The gills in this species have a somewhat wavy margin as well as being notched and, while the majority of the longer ones are forked, most of the shorter are distinct.

This is the only collection which has been made of this fungus in the Philippines since Cuming's collection of the type, between 1836 and 1840. In the meanwhile the species has been collected in northern India.

LENZITES PLATYPHYLLA Lév. Ann. Sci. Nat. Bot. III. **2**: 179. 1844. Not Cooke.

LUZON: Province of Nueva Vizcaya, vicinity of Dupax, January–April, 1912, *R. C. McGregor, Bur. Sci. 14353. 20284;* Province of Bataan, Lamao, November, 1909, *H. M. Curran, For. Bur. 19188;* Mount Mariveles, January, 1910, *H. M. Curran, For. Bur. 19244a,* MINDANAO: District of Davao, Lake Lanao, Camp Keithley, September, 1907, *Mary S. Clemens.*

Collected previously in Java and Guiana.

LENZITES STRIATA (Swartz) Fr. Epicr. Myc. 406. 1838.

Agaricus striatus Swartz, Prodr. Fl. Ind. Occ. 148. 1788.

Merulius striatus Lam. Encyc. Méth. Bot. **4**: 127. 1797.

Daedalea striata Fr. Syst. Myc. **1**: 334. 1821.

LUZON: Province of Bataan, Mount Mariveles, November 3–19, 1912, *P. W. Graff, Bur. .Sci. 19044,* at an elevation of 350 m., on decaying and burned logs.

Previously collected in tropical America, (including the West Indies,) Australia, and Borneo.

SCHIZOPHYLLUM Fries

SCHIZOPHYLLUM COMMUNE Fr. Syst. Myc. **1**: 330. 1821.

Agaricus multifidus Batsch, Elench. Fung. **1**: 124. *f. 126.* 1786.

Scaphophorus agaricoides Ehrh.; Nees, Hor. Phys. Berol. 94. 1820.

Schizonia vulgaris Pers. Myc. Eur. **3**: 14. 1828.
Schizophyllum alneum Schröt.; Cohn, Krypt. Flor. Schles. **3**: 383. 1887.

LUZON: Province of Rizal, Bosoboso, July, 1906, *M. Ramos, Bur. Sci. 1195*; Panay, Iloilo, January 2, 1904, *Copeland 29.*

A fungus of universal distribution living on woody hosts of all sorts, both as a saprophyte and as a facultative parasite. After gaining entrance beneath the bark of living trees, through wounds, this species is able to slowly advance through the tissues which are apparently killed in advance of the progress of the fungus.

CREPIDOTUS Fries

CREPIDOTUS POGONATUS Kalchbr. Grevillea **9**: 131. 1880.

LUZON: Province of Nueva Vizcaya, vicinity of Dupax, January 14, 1913, *R. C. McGregor, Bur. Sci. 20251*, on decaying twigs.

Previously collected in East Africa.

PANAEOLUS Fries

PANAEOLUS PAPILIONACEUS (Bull.) Fr. Epicr. Myc. 236. 1836.
Agaricus equinus Alb. & Schw. Consp. Fung. Lus. 3. 1805.
Agaricus campanulatus Linn. Sp. Plant. 1175. 1753.
Agaricus carbon Batsch, Elench. Fung. 6. 1783.
Agaricus papilionaceus Bull. Hist. Champ. France 561. 1791–1798.
Agaricus varius Pers. Icon. Des. Fung. 40. 1800.
Panaeolus campanulatus Berk. Outl. Brit. Fung. 175. 1860.
Copelandia papilionacea Bres. Hedwigia **53**: 51. 1912.

LUZON: Province of Cagayan, Aparri, March, 1909, *H. M. Curran, For. Bur. 17143;* vicinity of Manila, September, 1905, *Merrill 5008*. MINDANAO: District of Davao, March 5, 1904, *Copeland 344*.

The formation of the new genus *Copelandia*, in which the sole distinction from *Panaeolus* is the presence of cystidia, is inviting for the future a confusion similar to that existing in the genera *Panus* and *Lentinus*, where the only difference exists in the presence or absence of notched gills. This characteristic, even though at present confined to this one species, is not a sufficient distinction for a generic character, or to insure

the possible acceptance of this as the type of a new genus. It seems the wisest course, therefore, to continue as before with the use of the Friesian name, at least till some character more positive may be found to warrant the change.

Previously reported from the United States, Europe, South Africa, southern Siberia, Ceylon, Borneo, and Australia as well as the Phillippines.

UNIVERSITY OF MONTANA,
MISSOULA, MONTANA

Occurrence of the pycnial stage of Puccinia Taraxaci*

Louise Dosdall

On April 29, 1920, dandelions were found on University Farm, St. Paul, heavily infected with rust. In addition to the fact that this was the earliest date on record at the University of the occurrence of *Puccinia Taraxaci* (Rabent.) Plow., this collection was of particular interest because pycnia were found accompanying the uredinia. As far as could be discovered from the literature, this stage had never before been collected in North America, although both Plowright (1889) and Grove (1913) had reported its occurrence in England, and Jacky (1909) in Germany.

In the spring of 1921 a careful watch was kept for the first appearance of dandelion rust to determine whether or not the pycnial stage was common in this region. The first pycnia were found on University Farm, April 17, 1921. Subsequently they were found in various localities around St. Paul and Minneapolis. If a careful search was made, the pycnial stage could be found in almost any cluster of plants. A difference was noted in the abundance of the rust during the two seasons in which observations were made. In 1920 the pycnia were found accidentally in two localities. In both cases the infection on the plants was so conspicuous that the rust was observed while one was walking hurriedly through the field. In 1921 no pycnia could be found without the most diligent search.

Through correspondence with Dr. H. S. Jackson, it was learned that the pycnial stage of *Puccinia Taraxaci* had been collected at Brookville, Indiana, in April, 1918, by C. A. Ludwig, and the specimens deposited in the Arthur Herbarium. This specimen was compared with the Minnesota collection and the rusts found to be identical. In spite of the fact that collections are rare, it would seem that the occurrence of the pycnial stage must be rather common.

The pycnia of *Puccinia Taraxaci* are amphigenous on yellow, slightly swollen spots, which occur frequently along the midrib

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of the leaf but are found sometimes on the blade. They are reddish brown in color, subglobose in shape, about 90μ in diameter and 76μ in height. Ostiolar filaments are present. Uredinia appear on the same spots soon after the pycnia.

Midwinter botanizing in southern Arizona

EDWIN B. BARTRAM

As a large part of the literature relating to the desert flora of Southern Arizona is not readily accessible to any but professional botanists the following brief survey of the recognizable winter plants in the region tributary to Tucson may prove interesting and helpful to those fortunate enough to make the acquaintance of this fascinating country in the early months of the year.

From a botanical point of view the area is obviously more closely related to the Mexican state of Sonora than it is to any of our possessions so that many of its most characteristic plants are not represented at all in Wooton and Standley's invaluable Flora of New Mexico.

The preparation of specimens in this dry sunny climate is a simple operation; the surrounding mountains, or at least their foothills, are easy of access; and, as the representation of Arizona plants in most of our larger eastern herbaria is quite meagre, the ambitious collector finds an almost unlimited field in which to work. A surprising variety of flowers is evident even at this season and many plants whose period of bloom is past are recognizable by some peristent vestige of fruit or flowers.

Apart from such unique and unfamiliar plants as the sahuaro, chollas, candle bush, prickly pears and palo-verde, which claim the undivided attention of the newcomer until the novelty and charm of the first impressions are to a certain extent dulled by familiarity, the most striking feature of the desert vegetation is the isolation of various clearly defined plant communities. It is all desert, to be sure, but the wide gravel plains over which *Covillea glutinosa* is dominant and the barren spurs and talus slopes, sun baked, arid and almost devoid of plant life, excepting the hardiest drought-resisting species that have become inured to this environment, seem to resolve themselves readily into a series of barriers that from necessity restrict the distribution of many species to quite definitely circumscribed limits.

Distances in Arizona are proverbially deceptive, but we were hardly prepared to learn that the lower slopes of the Santa Catalina Mountains, which looked so enticingly near, were at

least fifteen miles away instead of under five miles as we had fondly imagined. The horses are willing and capable of covering thirty miles or more in a day without discomfort, but the first days experience proved conclusively that the one indispensable article of equipment was a good canteen; for, excepting a few canyons in the Catalina Range reaching well back into the forested and snow-covered slopes, water is never available. The higher peaks are heavily snow-capped during most of the winter months, although snow rarely descends to the level of the plains. After a rainy night in January it is not unusual to see the snow line across the slopes as straight as though it had been drawn with a ruler. In the sheltered canyons where snow rarely falls and never persists we found many flowering plants in early January which were materialy increased in number and variety with each succeeding week. Many plants are distributed generally over entire ranges but in each canyon, walled in by the steep arid intervening ridges, we found some species that were wanting in every other locality we visited.

Sabino Canyon in the Santa Catalina Mountains, distant some sixteen miles from Tucson, is one that we happened to reach quite frequently and will serve nicely as an example of these interesting localities. Leaving early we drive across the plains through miles of pungent greasewood with its curiously folded leaves and bright yellow flowers, which even now are giving way to the little felted spheres of fruit. Thickets of cholla, six or eight feet high, varying in color from pale green to ruddy brown and brightened with pendant clusters of orange colored fruit, glow in the early sunlight. *Cirsium neomexicanum*, *Lesquerella Fendleri*, and *Baileya multiradiata* are in bloom along the roadsides, the stiff wands of old fruit bend over colonies of gray-green *Atriplex canescens*, and here and there an occasional *Yucca elata* lifts its brown panicle of old fruit above the shrub level. In a broad belt along the base of the mountains the sahuaro gives a grass green tinge to the foothills ten miles away where the arroyos are marked by wavering lines of mesquite and desert willow. The hot rocky slopes flanking the mouth of the canyon are spotted with *Opuntia Bigelovii*, glistening like spicules of glass in the brilliant sunshine and undoubtedly the most vicious of all the chollas. A carpet of detached joints covers the ground about every plant, and woe to the unwary

walker who steps unguardedly into these precincts. The spines penetrate shoe leather like a steel needle and refuse to be withdrawn. Nature guards her wards well in these desert places and the animals, profiting by the example, guard their dens with a pile of these bristling joints, carried one by one at a cost easy to be reckoned by anyone unfortunate enough to have brushed against a stem in an unguarded moment.

Along the creek issuing from the canyon are many waifs from the higher zones, such as *Juniperus scopulorum*, *Yucca baccata*, *Quercus Emoryi*, *Q. oblongifolia* and *Q. hypoleuca*, but it is among the rocks on sheltered slopes in the canyon that we find the earliest flowers. Here the fairy dusters, *Calliandra eriophylla*, are just spreading their delicate balls of pink bloom, and clumps of *Lesquerella purpurea* are established in many congenial crevices. *Hermannia pauciflora* with the flowers well concealed among the matted woody stems is easily overlooked, and a form of *Anislotus puberulus* with showy golden yellow flowers and nearly leafless stems helps to brighten the otherwise barren ledges. *Notholaena Lemmoni* grows abundantly among the rocks of a dry sunny slope, while the shaded crevices and fissures give harbour to such species as *Pellaea mucronata*, *Cheilanthes Lindheimeri* and various mosses, among which *Tortula inermis*, *T. ruralis*, *Barbula Manniae* and *B. chloronotus* are the most in evidence. Where almost any other living thing would wither and perish *Agave Parryi* and *Dasylirion Wheeleri* spread over the ledges and boulders in flourishing clumps that lend a characteristic touch to this unique landscape.

The region about Picture Rocks was another productive locality that proved interesting enough to warrant trips at intervals of about ten days. Some twelve miles west of Tucson, near the far end of the Tucson Mountains in a broad gully fronting the old Indian pictographs, from which the place takes its name, *Anemone sphenophylla* was just coming into bloom on January twelfth, white clusters of *Dryopetalon runcinatum* brightened many of the damp rock fissures, the trim little *Thysanocarpus amplectens* grew sparingly in nearly every depression where sufficient soil had accumulated to support a short span of life during the season of winter rains, while various winter annuals, such as *Lepidium lasiocarpum*, *Draba cuneifolia* and *Amsinckia Menziesii*, were scattered sparingly in the shelter

of shrubs or rocks wherever a bit of moisture and shade was obtainable. Along the dry arroyos leading off through the mountains *Anislotus brachycarpus* and *A. trispermus* were just opening their first flowers, and on the dry flanking talus slopes the omnipresent *Encelia farinosa* in full bloom was temporarily forgotten in the pleasure incident to finding a patch of *Polygala macradenia* with inconspicuous little purple flowers barely visible even at close range.

A similar association of species, including *Dryopetalon*, *Anemone* and *Thysanocarpus*, was observed on the shaded side of a steep ridge at Robles Pass, where scattered pockets of soil had been formed by the disintegrating mosses and lichens, and no doubt a more thorough survey of the region would disclose many similar localities; but the complete isolation of these stations, one from another, is the one factor that seems to be repeatedly emphasized.

Theorizing is always interesting, often productive, but sometimes misleading, yet in the light of these facts one can hardly reject the inference that at some comparatively recent time the forms of plant life, not fitted to thrive in the arid gravel and rock formations of the desert as we find it today, were more widely distributed than they are now, and by progressive changes have been isolated by the rising tide of desert vegetation. Such a condition is plain in outline but difficult to translate into terms that are applicable when the available data are so meagre. Inequality in the distribution of rainfall, the processes of erosion and disintegration and variations in climatic conditions have been some of the contributing causes to the spread and contraction of the various plant communities as we now know them, but to what extent these influences have operated and in what manner the distribution has been modified by complicated cross currents of action and reaction are queries that may be more satisfactorily answered at some future time, when our knowledge of the subject will be more intimate and comprehensive than it is now.

The following list of species, collected between December 23d, 1919, and January 26th, 1920, may be considered as fairly representative of the region within a radus of fifteen miles from Tucson but is necessarily incomplete. Many of the plants listed were in flower and nearly all of them provided with

fruit in a sufficiently good state of preservation to make them easily recognizable.

For assistance in the determination of many of the species I am much indebted to the kindness of Dr. Paul C. Standley.

CHEILANTHES LINDHEIMERI Hook. Frequent on arid ledges and rocky slopes.

CHEILANTHES MYRIOPHYLLA Desv. Less common than the preceding.

CHEILANTHES PRINGLEI Davenp. The finely dissected delicate fronds of this species distinguished it at once from its associates in this region. Infrequent in shaded rock clefts on the lower slopes.

CHEILANTHES WRIGHTII Hook. Infrequent but easily recognized by the smooth green pinnules and lustrous channelled stipes.

NOTHOLAENA HOOKERI D. C. Eaton. Rather common among rocks on arid hillsides. The characteristic outline of the fronds and the bright yellow color of the lower surface are unmistakable marks.

NOTHOLEANA SINUATA (Sw.) Kaulf. Frequent among dry rocks on the lower mountain slopes.

NOTHOLAENA SINUATA INTEGERRIMA Hook. More widely distributed than the typical form of the species.

NOTHOLAENA BONARIENSIS (Willd.) C. Chr. Rare among rocks near the mouth of Sabino Canyon.

NOTHOLAENA LEMMONI D. C. Eaton. Abundant on a dry rocky slope in the mouth of Sabino Canyon but not found elsewhere.

PELLAEA MUCRONATA D. C. Eaton. Ledges and crevices in the foothills. This seems to be the commonest fern of the region.

SELAGINELLA ARIZONICA Maxon. A recently described species forming flat green mats among rocks in the arroyos.

SELAGINELLA RUPICOLA Underw. The grayish color and erect habit are good field marks for this species. Near the mouth of Sabino Canyon it forms dense turfy mats over the dry ledges.

JUNIPERUS SCOPULORUM Sarg. Bank of stream near the mouth of Sabino Cañyon. Evidently a stray from the higher ridges.

EPHEDRA TRIFURCATA Torr. Abundant along washes in the gravel plains.

EPHEDRA ANTISYPHILITICA Meyer. Rare in an arroyo near Picture Rocks. The slender flagellate stems give this plant a very different aspect from the more common, stiffly erect, *E. trifurcata*.

EPHEDRA VIRIDIS Coville. Collected but once in the dry foothills at Robles Pass.

ANDROPOGON SACCHAROIDES Sw. Frequent on the plain and foothill.

HETEROPOGON CONTORTUS (L.) Roem. & Schult. More confined to the foothill slopes.

CHAETOCHLOA MACHROSTACHYA (H. B. K.) Scribn. & Merr. Rare on talus slopes at Robles Pass.

CHAETOCHLOA VIRIDIS (L.) Scribn. Introduced in fields and waste places.

ARISTIDA ADSCENSIONIS L. Frequent on hillsides in the Tucson Mountains.

ARISTIDA WRIGHTII Nash. Uncommon on dry slopes in the Tucson Mountains.

ARISTIDA BROMOIDES H. B. K. Common in the foothills. Spikelets developing through the winter.

ARISTIDA DIVERGENS Vasey. Dry slopes in the mouth of Sabino Canyon.

MUHLENBERGIA DUMOSA Scribn. A unique species confined to ledges along the trail in Sabino Canyon at about 3000 feet elevation.

MUHLENBERGIA MICROSPERMA (D C.) Kunth. Rare in the dry foothills.

MUHLENBERGIA PORTERI Scribn. Common in the shelter of shrubs on the gravel plains.

EPICAMPES RINGENS Benth. Slopes in the mouth of Sabino Canyon.

BOUTELOUA FILIFORMIS (Fourn.) Griffiths. Flowering plants collected in Sabino Canyon on January 3d.

BOUTELOUA ROTHROCKII Vasey. The dark brown spikelets persist well through the winter.

BOUTELOUA PARRYI (Fourn.) Griffiths. This and the preceding species are abundant near Robles Pass.

TRICHLORIS FASCICULATA Fourn. Roadsides south of Tucson.

DASYOCHLOA PULCHELLA (H. B. K.) Willd. Generally distributed over the plains.

KOELERIA CRISTATA (L.) Pers. Along streams in the foothills of the Santa Catalina Mountains.

ERAGROSTIS MEGASTACHYA (Koel.) Link. A weed of waste places.

POA BIGELOVII Vasey & Scribn. Confined to damp ledges near Picture Rocks.

CYPERUS CYRTOLEPIS Torr. & Hook. Edge of stream east of Pima Canyon.

JUNCUS NODOSUS L. Edge of stream in Pima Canyon.

YUCCA ELATA Engelm. Single plants scattered over the plains but nowhere abundant.

YUCCA BACCATA Torr. Thickets in the mouth of Sabino Canyon. Apparently washed down from the higher levels.

NOLINA MICROCARPA S. Wats. With the preceding.

DASYLIRION WHEELERI S. Wats. On dry ledges in the foothills.

DIPTEROSTEMON PAUCIFLORUS (Torr.) Rydb. Sparingly in flower along an arroyo near Picture Rocks.

AGAVE PARRYI Engelm. On dry ledges in the mouth of Sabino canyon.

POPULUS WISLIZENI (S. Wats.) Sarg. Catkins fully developed and falling by late January.

QUERCUS ARIZONICA Sarg. Scattered along the creek near the mouth of Sabino Canyon.

QUERCUS EMORYI Torr. With the preceding but more abundant and larger.

QUERCUS HYPOLEUCA Engelm. Sterile but easily recognized by the leathery leaves densely white woolly beneath.

QUERCUS OBLONGIFOLIA Torr. This and the preceding species of oaks are all confined to the lower end of Sabino Canyon, where they seem to exist as waifs carried down by the stream from higher levels in the region about Mt. Lemmon.

CELTIS PALLIDA Torr. Frequent along arroyos in the Tucson Mountains.

PARIETARIA OBTUSA Rydb. Localized on a shaded ledge near Picture Rocks.

PHORADENDRON MACROPHYLLUM (Engelm.) Cockerell. Abundant on *Populus* in the plains and foothills.

PHORADENDRON CALIFORNICUM Nutt. The abundant small red berries and bare stems make a very attractive combination. Chiefly on Mesquite in the plains.

ERIOGONUM POLYCLADON Benth. Recognizable but long past flowering.

ERIOGONUM PINETORUM Greene. Long past flowering but leaves and fruit persistent enough for identification.

ERIOGONUM WRIGHTII Torr. Widely distributed over arid rocky slopes in the foothills.

RUMEX HYMENOSEPALUS Torr. Common in sandy areas throughout the plains.

POLYGONUM PUNCTATUM Ell. Edge of stream in the foothills of the Santa Catalina Mountains.

ATRIPLEX CANESCENS (Pursh) Nutt. Several forms of this species are abundantly over the plains.

ATRIPLEX ROSEA L. Young plants in the sandy bed of an arroyo near Picture Rocks.

CHENOPODIUM PAGANUM Reichenb. Sparingly introduced in waste places.

AMARANTHUS PANICULATUS L. A common weed of fields and waste places.

WEDELIELLA INCARNATA (L.) Cockerell. Flowering sparingly in sunny talus slopes in the foothills.

HESPERONIA RETRORSA (Heller) Standl. Dry slopes near Picture Rocks.

COMMICARPUS SCANDENS (L.) Standl. Localized in rock clefts along an arroyo west of Tucson.

ANEMONE SPHENOPHYLLA Poepp. Frequent among rocks along arroyos in the foothills. In full flower by mid-January.

CLEMATIS DRUMMONDII Torr. & Gray. Frequent on the plains west of Tucson.

ESCHSCHOLTZIA MEXICANA Greene. A few flowers on sheltered banks in January.

THYSANOCARPUS AMPLECTENS Greene. Locally abundant in damp pockets near Picture Rocks and at Robles Pass. Sparingly in flower on January 12th but plentiful and in mature fruit ten days later. The curious disk-shaped pods with perforated wing margins mark this off at once from all other crucifers of the region.

STREPANTHUS ARIZONICUS S. Wats. Frequent in the shade of bushes near Picture Rocks.

LEPIDIUM HIRSUTUM Rydb. Infrequent on lower slopes of Santa Catalina Mountains.

LEPIDIUM LASIOCARPUM Nutt. Common in sandy plains and dry washes.

LESQUERELLA FENDLERI (Gray) S. Wats. Flowering early along dry roadsides and on open slopes in the foothills.

LESQUERELLA PURPUREA (Gray) S. Wats. An attractive early flower of rock crevices in the foothills and lower slopes of the canyons. In vigorous tufts the stems sometimes attain a length of nearly two feet.

DRABA CUNEIFOLIA Nutt. Widely distributed on shaded knolls and banks along the arroyos.

ARABIS PERENNANS S. Wats. The purple flowers give quite a touch of color to the ledges along the arroyos west of Tucson.

BRASSICA NIGRA (L.) Koch. Occasional in cultivated fields.

SOPHIA OCHROLEUCA Wooton. Frequent in sheltered shady spots.

DRYOPETALON RUNCINATUM Gray. Rather local in damp shaded rock pockets. The delicate white flowers form a pleasing contrast with their rough arid setting.

SEDUM GRIFFITHSII Rose. Ledges in Sabino Canyon.

FENDLERA RUPICOLA Gray. Ledges in Sabino Canyon. Leaves and old fruit persistent.

PHILADELPHUS MICRPOHYLLUS Gray. Frequent on open rocky slopes in the foothills. In sheltered places the flowers were opened in profusion by mid January.

PLATANUS WRIGHTII S. Wats. In the mouth of Sabino Canyon.

VAUQUELINA CALIFORNICA (Torr.) Sarg. Ledges in Sabino Canyon at about 300 feet elevation.

CALLIANDRA ERIOPHYLLA Benth. One of the most attractive of the early spring flowers. Abundant on open rocky slopes in the foothills.

ACACIA CONSTRICTA Benth. Frequent on the plains. Pods more persistent than *A. Greggii.*

ACACIA GREGGII Gray. This and *A. constricta* are characteristic thorny shrubs of the gravel plains.

PROSOPSIS GLANDULOSA Torr. This is the main source of firewood for the region.

ACUAN JAMESII (Torr. & Gray) Kuntze. Pods persistent through the winter.

CASSIA COVESII Gray. Scattered sparingly over the open gravel plains. Pods and leaves persistent.

HOFFMANSEGGIA DENSIFLORA (Benth.) Gray. On sandy plains. Pods persistent.

PARKENSONIA MICROPHYLLA Torr. A thorny shrub or small tree of the foothills and adjacent plains. On sheltered sunny slopes a few flowers were in evidence by late January.

CERCIDIUM TORREYANUM Sarg. A low nearly leafless shrub occuring sparingly along washes in the plains.

KRAMERIA GLANDULOSA Rose & Painter. A straggling flowerless shrub of the plains with soft silky pubescent young growth.

ANISLOTUS BRACHYCARPUS (Benth.) Rydb. The broad leaflets and villous pubescence separate this species sharply from the following where they grow together.

ANISLOTUS TRISPERMUS (Greene) Woot. & Standl. With the preceding in a sandy bed of an arroyo near Picture Rocks. Just coming into flower.

ANISLOTUS PUBERULUS (Benth.) Woot. & Standl. What seems to be a form of this species was in full flower on the ledges of Sabino Canyon at about 3000 feet elevation.

PAROSELLA PARRYI (Torr. & Gray.) Heller. This inconspicuous little plant is quite typical of arid rocky hillsides in the foothills.

PAROSELLA GREGGII (Gray) Heller. Abundant on rocky spurs and slopes near Agua Calgiente but not observed elsewhere.

NISSOLIA SCHOTTII (Torr.) Gray. Pods and leaves persistent. Frequent.

ASTRAGALUS NUTTALLIANUS DC. Local on the plains. In flower in January.

CRACCA TENELLA Gray. Localized on dry sunny ledges near Robles Pass.

GALACTIA WRIGHTII Gray. Twining over low bushes in the foothills. Leaves and pods persistent.

OLNEYA TESOTA Gray. Foothill slopes and nearby plains.

ERODIUM CICUTARIUM (L.) L'Her. Abundant in waste places and on open sandy plains.

ERODIUM TEXANUM Gray. Gravelly Knolls near Picture Rocks.

COVILLEA GLUTINOSA (Engelm.) Rydb. The most abundant and characterisitc shrub of the plains.

KOEBERLINIA SPINOSA Zucc. Frequent on knolls and in thickets in the plains.

JANUSIA GRACILIS Gray. Twining about bushes on open rocky hillsides.

RUTOSMA PURPUREA Woot. & Standl. Frequent on banks of the arroyos west of Tucson.

POLYGALA MACRADENIA Gray. Confined to a rocky hillside near Picture Rocks.

EUPHORBIA CAPITELLATA Engelm. Forming quite showy mats on ledges and in crevices along the arroyos west of Tucson.

EUPHORBIA PEDICULIFERA Engelm. A form with densely glandular pubescent stems and leaves is not uncommon.

EUPHORBIA POLYCARPA Benth. This and the two preceding species of the genus are freely distributed over the arid ridges and talus slopes. They all belong to the group of perennials with entire pubescent leaves and vary considerably in habit and appearance.

DITAXIS NEOMEXICANA (Muell. Arg.) Heller. The lax straggling habit of this species is very different from the stiff erect form of *D. sericophylla.*

DITAXIS SERICOPHYLLA (Gray) Heller. With the preceding on rocky slopes at Robles Pass.

CALLITRICHE PALUSTRIS L. In shallow water at the mouth of Sabino Canyon.

SIMMONDSIA CALIFORNICA Vutt. A striking evergreen bush of the dry plains and foothills with leathery leaves and yellow flowers in drooping axillary clusters.

DODONAEA VISCOSA L. Abundant along the stream bank in the mouth of Sabino Canyon.

CONDALIA SPATHULATA Gray. Banks of arroyos near the foothills. Leaves and fruits persistent.

RHAMNUS TOMENTELLA Benth. Ledges in Sabino Canyon at about 3000 feet elevation.

HIBISCUS COULTERI Harv. Flowering sparingly through the winter.

HIBISCUS DENUDATUS Benth. The pale almost leafless stems and delicately tinted pink flowers give this plant an attractive personality. Rare on open slopes at Robles Pass.

GAYOIDES CRISPUM (L.) Small. Frequent on rocky slopes.

ABUTILON INCANUM (Link) Sweet. Common on rocky hillsides. Leaves and carpels persistent.

SPHAERALCEA AMBIGUA Gray. A polymorphous species widely scattered over the region. Flowers white or pink and leaves varying greatly in outline.

SPHAERALCEA GROSSULARIAEFOLIA York. On rocky slopes at Robles Pass.

HERMANNIA PAUCIFLORA S. Wats. Confined to rocky slopes near the mouth of Sabino Canyon.

AYENIA PUSILLA L. Frequent on the dry gravel plains.

FOUQUIERIA SPLENDENS Engelm. Although the leaves were well developed in sunny sheltered places no flowers were in evidence by the end of January.

OPUNTIA FULGIDA Engelm. Common on the plains.

OPUNTIA ARBORESCENS Engelm. Forming impenetrable thickets on the plains.

OPUNTIA LEPTOCAULIS DC. The common slender stemmed cholla of the region.

OPUNTIA BIGELOVII Engelm. Frequent on arid rocky slopes in the foothills.

OPUNTIA CHOLOROTICA Engelm. & Bigel. On ledges near the mouth of Sabino Canyon.

OPUNTIA TOUMEYI Rose. Frequent on the gravel plains.

MAMILLARIA GRAHAMI Engelm. Frequent in small colonies among rocks in the foothills. The diminutive scarlet pipe-shaped fruits are very attractive.

ECHINOCACTUS WISLIZENI Engelm. Scattered sparingly over the foothill slopes. Some plants are well over a meter in height.

ECHINOCEREUS FENDLERI (Engelm.) Rümpl. Forming clumps in gravel plains near the foothills.

CEREUS GIGANTEUS Engelm. The sahuaro well merits the reputation of being one of the most unique and striking elements of the desert vegetation.

DAUCUS PUSILLUS Mx. Scarce on shaded knolls in the washes.

PLUMBAGO SCANDENS L. In the foothills of the Santa Catalina Mountains. Leaves and fruit persistent.

FORESTERIA PHILLYREOIDES Torr. This is a Mexican type and Dr. Standley informs me they have but one other specimen from the United States, collected at Tucson by Pringle. The staminate flowers were fully developed by December 30th and a few leafy shoots supplied the foliage characters. On rocky slopes along the Ajo road west of Tucson.

FRAXINUS ATTENUATA Jones. In the mouth of Sabino Canyon.

MENODORA SCABRA Gray. On arid slopes of the Tucson Mountains.

HAPLOPHYTON CIMICIDUM A. DC. Rare on rocky talus slopes at Robles Pass.

ASCLEPIAS LINARIA Cav. Frequent on ledges in the lower slopes of the Santa Catalina Mountains.

PHILIBERTELLA LINEARIS Gray. Twining over bushes on dry rocky hillsides.

EVOLVULUS LINIFOLIUS L. An inconspicuous little perenial with fugitive flowers. Frequent among rocks and dry ledges in the foothills.

JACQUEMONTIA PRINGLEI Gray. Not uncommon on rocky hillsides. Leaves and capsules persistent.

PECTOCARYA LINEARIS (R. & P.) DC. Locally abundant on a gravel shelf near Picture Rocks.

AMSINCKIA MENZIESII (Lehm.) Nels. & Macb. Flowering with *Thysanocarpus* and *Dryopetalon* on shaded ledges at Picture Rocks.

VERBENA WRIGHTII Gray. This is one of the showiest of the early flowers in the foothills, where it blooms profusely in January.

VERBENA XUTHA Lehm. Rare and local on dry slopes of the Tucson Mts.

LIPPIA WRIGHTII Gray. Rocky slopes in the foothills. Leaves and nutlets persistent.

MARRUBIUM VULGARE L. A very common weed of roadsides and waste places.

MESOSPHAERUM EMORYI (Torr.) Kuntze. Flowering through the winter and very characterisric of arid rocky slopes in the foothills.

HEDEOMA OBLONGIFOLIA (Gray) Heller. Ledges in the mouth of Sabino Canyon.

HEDEOMA NANA (Torr.) Greene. In rock crevices along arroyos west of Tucson. The leaves and fruit of this and the preceding are persistent through the winter.

SALVIA PINGUIFOLIA (Fernald) Woot. & Standl. On rocky hillside at Robles Pass. Buds well developed but not in flower.

NICOTIANA TRIGONOPHYLLA Dunal. A common plant of dry ledges in the foothills. In flower throughout the winter.

NICOTIANA GLAUCA Graham. An introduced shrub of waste places.

LYCIUM COOPERI Gray. Frequent on rocky slopes.

LYCIUM FREMONTII Gray. Ledges at the mouth of Sabino Canyon. In full flower on January 6th.

LYCIUM PARVIFLORUM Gray. A thorny straggling shrub of the gravel plains.

LYCIUM TORREYI Gray. Confined to the slopes near Picture Rocks.

PHYSALIS IXOCARPA Brot. Infrequent in the Tucson Mountains.

ANTIRRHINUM ANTIRRHINIFLORUM (Willd.) Hitchc. On slopes of the Tucson Mountains. Leaves and capsules persistent.

SCROPHULARIA PARVIFLORA Woot. & Standl. Flowering sparingly on January 20th in the mouth of Pima Canyon, Santa Catalina Mountains.

PENTSTEMON SUPERBUS A. Nels. Sandy washes in the foothills. Flowering freely in January.

MIMULUS LANGSDORFII Don. Shallow water in a brook east of the mouth of Pima Canyon.

MECARDONIA PEDUNCULARIS (Benth.) Small. Abundant in a brook east of the mouth of Pima Canyon. This species seems to flower and mature fruit throughout the winter.

STEMODIA DURANTIFOLIA (L.) Sw. In shallow water with the two preceding.

DIAPEDIUM TORREYI (Gray) Woot. & Standl. Arid slopes near Agua Caliente. The large cordate bracts, fading white and papery, give this plant a unique appearance in the field.

CARLOWRIGHTIA ARIZONICA Gray. Leaves and capsules persistent enough for identification.

SIPHONOGLOSSA LONGIFLORA (Torr.) Gray. Frequent on arid slopes west of Tucson. Leaves and capsules persistent.

RUELLIA TUBEROSA OCCIDENTALIS Gray. Infrequent near Picture Rocks. Old capsules persistent.

CHILOPSIS LINEARIS (Cav.) Sweet. Along arroyos in the foothills.

STENOLOBIUM INCISUM Rose & Standl. Rocky ledges and crevices among the foothills. The persistent leaves and showy yellow capsules make this a clean and attractive plant throughout the winter.

GALIUM STELLATUM Kellogg. This plant makes considerable growth from a diffuse woody base during the winter, but there was no evidence of bloom by January 30th. Frequent on ledges and rocky hillsides.

SAMBUCUS MEXICANA Presl. Frequent along water courses and in cultivation. In bloom by mid-January.

PTILORIA PAUCIFLORA (Torr.) Raf. A common plant of the arid plains and foothills blooming through the winter.

PEREZIA WRIGHTII Gray. In full flower on January 21st. Infrequent on arid rocky slopes near Picture Rocks.

TRIXIS CALIFORNICA Kellogg. In full flower during January. Abundant and quite showy among rocks in the foothills.

HYMENOCLEA MONOGYRA Torr. & Gray. A tall slender weed-like shrub with persistent filiform leaves and winged fruit. In the mouth of Pima Canyon.

FRANSERIA DELTOIDEA Torr. One of the characteristic plants of dry gravel plains near the foothills. Buds well developed by January 30th but no flower.

EUPATORIUM SOLIDAGINIFOLIUM Gray. Ledges at the mouth of Sabino Canyon.

COLEOSANTHUS BACCHARIDEUS (Gray) Kuntze. Infrequent on ledges near the mouth of Pima Canyon. Leathery leaves and flower heads very persistent.

COLEOSANTHUS COULTERI (Gray) Kuntze. Common on rocky hillsides.

COLEOSANTHUS WRIGHTII (Gray) Britton. Ledges in the mouth of Sabino Canyon.

GYMNOSPERMA CORYMBOSUM DC. Confined to the mouth of Pima Canyon.

GUTIERREZIA GLOMERELLA Greene. Leaves and old heads persistent. Frequent on the plains.

SIDERANTHUS AUSTRALIS (Greene) Rydb. Common on the gravel plains.

ISOCOMA HARTWEGI (Gray) Greene. Forming dense clumps on ridges and knolls in the gravel plains.

CHRYSOMA LARICIFOLIA (Gray) Greene. Rock clefts and ledges in the arid foothills. Flowering casually through the winter months.

BACCHARIS GLUTINOSA Pers. Common along the banks of Rillito Creek.

BACCHARIS SAROTHROIDES Gray. Abundant on the sand bars and banks of Rillito Creek.

ERIGERON DIVERGENS Torr. & Gray. This is apparently an abnormal winter form of the species but very constant throughout the region. It is scattered freely over the rocky foothill slopes and flowers during January.

GNAPHALIUM WRIGHTII Gray. Frequent on arid rocky slopes.

PARTHENIUM INCANUM H. B. K. A common low shrub of the foothills. In good conditions through the winter,

CRASSINA PUMILA (Gray) Kuntze. Occurring sparingly on dry gravelly mesas.

ENCELIA FARINOSA Gray. The distinctive gray color of many of the desert slopes is derived from the lustrous silvery leaves of this species. The showy yellow flowers are locally abundant, even in January, and it may well be numbered among the most satisfying and attractive plants of the region.

LEPTOSYNE ARIZONICA Gray. Bank of a stream in the mouth of Pima Canyon.

POROPHYLLUM JUNCIFORME Greene. A rush-like plant of ledges and rocky slopes in the foothills.

DYSODIA POROPHYLLOIDES Gray. Rare on ledges near Picture Rocks.

PSILOSTROPHE COOPERI (Gray) Greene. Fresh flowers among the persistent papery old blooms are found sparingly in January. Frequent on the gravel plains.

BAILEYA MULTIRADIATA Harv. & Gray. Frequent and showy in sandy plains, especially along roadsides. Flowering freely by late January.

PERITYLE DISSECTA Gray. An attractive little plant with curiously cleft leaves and persistent involucres. In rock clefts near the mouth of Pima Canyon.

BAHIA DEALBATA Gray. Arroyos in the Tucson Mountains.

HELENIUM MONTANUM Nutt. Localized along the bank of a stream east of the mouth of Pima Canyon.

ARTEMISIA ALBULA Wooton. Arid foothill slopes. Abundant near Agua Caliente.

ARTEMISIA BRITTONII Rydb. Ledges in Sabino Canyon.

BEBBIA JUNCEA (Benth.) Greene. An attractive slender stemmed plant of the sandy plains.

SENECIO LEMMONI Gray. Flowering rather sparingly on rocky slopes in the foothills.

CIRSIUM NEOMEXICANUM Gray. Infrequent along roadsides in the gravel plains.

BUSHKILL, PENNSYLVANIA

Two new genera of Cactaceae

N. L. Britton and J. N. Rose

In our recent study of the genus *Echinocactus*, we have segregated a number of new genera, and restored several previously published, among which are *Malacocarpus*, *Gymnocalycium*, and *Discocactus*, all composed of species native to South America. Among the North American segregates are the two described below, which do not belong even to the same subtribe as *Echinocactus*.

THELOCACTUS (Schumann)

Echinocactus subgenus *Thelocactus* Schumann, Gesamtb. Kakteen 429. 1898.

Cacti of medium size, one-jointed, solitary or caespitose, globose or somewhat depressed, spiny, often densely so; ribs few, low or even indistinct, often spiraled, divided into large tubercles, the flowering ones more or less grooved above; flowers from near the center of the plant, borne on very young tubercles, rather large for the subtribe, campanulate, diurnal; scales on the ovary usually few, their axils naked; fruit, so far as known, dry, dehiscing by a basal pore; seeds numerous, black, finely tuberculate, with a large basal hilum.

Type species: *Echinocactus hexaedrophorus* Lemaire.

The generic name refers to the tubercled ribs.

1. **Thelocactus hexaedrophorus** (Lemaire) comb. nov.
   Echinocactus hexaedrophorus Lemaire, Cact. Gen. Nov. Sp. 27. 1839.

2. **Thelocactus bicolor** (Galeotti) comb. nov.
   Echinocactus bicolor Galeotti in Pfeiffer, Abbild. Beschr. Cact. 2: *pl. 25*. 1848.

3 **Thelocactus lophothele** (Salm-Dyck) comb. nov.
   Echinocactus lophothele Salm-Dyck, Allg. Gartenz. 18: 395. 1850.

NEOLLOYDIA gen. nov.

Small, more or less caespitose plants, fibrous-rooted, cylindric, one-jointed, densely spiny, tubercled; tubercles borne on spiraled ribs, grooved above; radial spines numerous, widely spreading;

central spines one to several, much stouter and longer than the radials; flowers large, pink or purple, subcentral from the axils of nascent tubercles, their segments widely spreading; fruit compressed-globose, dull colored, thin-walled, becoming papery, dry, with few scales or none; seeds globose, black, dull, tuberculate-roughened, with a large light basal scar.

Type species: *Mammillaria conoidea* De Candolle.

The genus is dedicated to Professor Francis E. Lloyd.

1. **Neolloydia conoidea** (De Candolle) comb. nov.

Mammillaria conoidea De Candolle, Mém. Mus. Hist. Nat. Paris **17**: 112. 1828.

Echinocactus conoideus Poselger, Allg. Gartenz. **21**: 107. 1853.

2. **Neolloydia Beguinii** (Weber) comb. nov.

Echinocactus Beguinii Weber in Schumann, Gesamtb, Kakteen 442. 1898.

INDEX TO AMERICAN BOTANICAL LITERATURE
1908–1921

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to foresty, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

This Index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of three cents for each card. Selections of cards are not permitted; each subscriber must take all cards published during the term of his subscription. Correspondence relating to the card issue should be addressed to the Treasurer of the Torrey Botanical Club.

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BULLETIN

OF THE

TORREY BOTANICAL CLUB

SEPTEMBER, 1922

New species of trees of medical interest from Bolivia

H. H. Rusby

The botaincal work of the Mulford Biological Exploration of 1921–22 was directed specially toward the investigation of medicinal plants. The distinctly pharmacological features of these plants will be discussed in the medical and pharmaceutical literature, but such unknown species as are encountered should be cited in botanical publications. Two problems of exceptional interest were connected with the botanical origin of the two drugs, "coto" and "cocillana" or "guapi," and their spurious substitutes.

It has never been known what trees yield the coto and paracoto barks, although evident that they pertain to the Lauraceae. For many years, no genuine bark of either has reached our markets, and the use of their worthless substitutes has resulted in destroying the medical reputation of these valuable drugs. Through the careful work of my associate, Dr. O. E. White, of the Brooklyn Botanic Garden, it is now possible to describe the genuine coto tree, as well as its principal substitute, and to provide for the supply of the genuine drug in future. · The bark of a second substitute, with leaf-bearing branches, was also collected, but the species cannot be determined from this material, though undoubtedly pertaining to the genus *Nectandra*.

Of cocillana or guapi bark, I collected not only the genuine species, but also the only substitute that has as yet been seen in commerce, besides two other species which, for special reasons, are liable to so appear in future.

The Bulletin for August (49: 223-258) was published August 31, 1922.

Those interested further in these subjects should consult future numbers of the Journal of the American Pharmaceutical Association.

Nectandra coto Rusby, sp. nov.

Young parts, inflorescence and lower leaf-surfaces densely and finely yellowish-tomentellate, the twigs stout. Mature leaves, including the petiole, 10–20 cm. long, 3–7 cm. wide, the petiole 2–3 cm. long, stout, sharply channelled above when dry, reddish brown; blade thick and coriaceous, regularly oblanceolate or slightly inequilateral, abruptly very short-pointed, the point acutish, the margin entire and sharply revolute, the upper surface glabrous and lustrous, drying brownish, the midrib reddish and channelled; lower surface pale, the midrib sharply prominent, the secondaries twelve to fourteen on each side, thin and crooked, lightly prominent, lightly anastomosing near the margin, the interspaces faintly reticulate. Inflorescence (very young in my specimen) axillary, the panicles small and loosely flowered, mostly long-peduncled, but shorter than their leaves even when in fruit, the peduncles and their branches coarsely and strongly angled. Bracts broadly ovate, thick, reddish, obtuse. Buds too young for dissection, appearing while the preceding mature fruit is still attached, tomentose. Calyx-limb wholly deciduous in fruit, the base almost concealing the fruit when young. Fruiting pedicel of variable length, thickened upward and becoming continuous with the calyx. Calyx-cup of mature fruit hard and thick, dark brown, roughly tuberculate, especially downward, broadly campanulate or subhemispherical, 2 cm. or more broad, the margin truncate, roughish, single but showing two distinct layers, the light brown fruit slightly projecting when mature, its summit lightly convex, finely granular or lightly mottled, bearing the very short, stout, acute style.

Mulford Biological Exploration Nos. 1048 and 1050. Collected by Dr. O. E. White as "Coto No. 1" (No. 1048) and "Coto No. 1a" (No. 1050), and under the native names "coto piquiante" and "coto fino." Mountains south of Huachi, near the Cochabamba River, Bolivia, at an altitude of 2500 to 3000 feet, September 9, 1921.

Dr. White's field notes are as follows:—

No. 1048.—A tree 50 to 60 feet high, with few branches except near the top and these short in comparison with the height of the tree. Bark of a cinnamon-brown color, peeling with difficulty, aromatic and very pungent, a few seconds after being chewed, the odor pungent when fresh. Wood of a sandal-wood yellow and a satiny luster, the trunk turning brown after being peeled. Leaves whitish beneath, dark- to light-green and glossy above. Young growth cinnamon-brown. Flower buds whitish. Cup of fruit brown-

green with brown spots, the fruit green, evidently of two generations on the same tree.

It is not possible to say with absolute certainty, from specimens collected in this stage of growth, whether this is a species of *Nectandra* or of *Ocotea*. The slender midribs and veins of the leaves are more those of *Ocotea* than of *Nectandra*, but the tomentose flower-buds are characteristic of *Nectandra*, the flowers of *Ocotea* being usually glabrous. There is no species of either *Nectandra* or *Ocotea* with which this can be identified.

Ocotea pseudo-coto Rusby, sp. nov.

Young growth and inflorescence whitish-puberulent, the lower surfaces of the mature leaves minutely and sparsely puberulent, the branchlets elongated and stout, little spreading, deep red, more or less angled. Leaves, including the petioles, 6–12 cm. long, 1.5–3 cm. broad, the petioles 1–1.5 cm. long, deep red, the upper surface nearly plane. Blades thick, oblong, acuminate at base and with a very abrupt short and stout obtuse point at the summit, the margin entire, not revolute, the upper surface brown when dry, glabrous, slightly lustrous, the midrib slightly prominent, sharply so underneath, the six to eight pairs of secondaries slender, ascending, obscurely connecting near the margin. Panicles axillary, less than half the length of their leaves, sessile or subsessile, broad, rather dense as seen in the young state. Bracts thickish, red, broadly ovate. Perigone thin, glabrous, undeveloped in the specimen. The other floral parts are too young for characterization.

Collected by Dr. O. E. White in the mountains south of Huachi, near the Cochabamba River, Bolivia, at an altitude of 2500 to 300 feet, September 9, 1921. Mulford Biological Exploration No. 1051, collected as "Coto No. 2" and under the name "coto ordinario." It is to be noted that the term "ordinario," as applied by these natives to any substance or article, has the significance that the article is of inferior quality.

Dr. White contributes the following field notes:—

Very large forest tree, growing with Nos. 1048 and 1050 and of the same general habit. Young buds only, and no fruit encountered. Bark thick and easily peeled, not specially aromatic and not pungent. The peeled wood remains white. Wood reddish-white internally.

The same difficulty of identification presents itself with this species as with No. 1050. The buds are a little more developed and the perigone characters are found to correspond with those of *Ocotea*.

The bark of this species is one of those that has very commonly occurred in commerce in this country under both names, coto and paracoto, but sold under either name it is absolutely spurious and medicinally worthless, so far as known.

Aerodiclidium benense Rusby, sp. nov.

Specimen in mature fruiting stage. Glabrous, the twigs numerous, rather slender, terete, densely leafy at the summit. Leaves, including the petiole, 10–15 cm. long, 3–5 cm. broad. Petioles 5–10 mm. long, slender, sharply channelled above. Blades thick and coriaceous, lustrous above, lanceolate, abruptly acuminate at base and summit, with acute apex, the midrib and slender venation scarcely prominent above, sharply so beneath. Principal secondaries five or six on each side, with short intermediate ones, strongly upcurved and connecting near the margin, the reticulation fine and sharp. Margin entire, very slightly revolute. Panicles axillary, less than half the length of their leaves, stoutly peduncled, having one to four shortly and stoutly pedicelled fruits, the pedicels strongly thickened upward. Calyx-cup subhemispherical, about 1.5 cm. broad, hard and thick, heavily wrinkled, its truncate summit with thin, sharp margin projecting slightly beyond the strongly recurved limb so as to form a double mouth, the limb thin, irregularly crenate-dentate. Fruit about 2 cm. long and two-thirds as broad, oval to ovoid, light brown, glabrous, strongly wrinkled at the base and very shortly stipitate, the rounded summit topped by the very short stout style.

Collected by Dr. O. E. White at the second portage of the Bopi River, Bolivia, at an altitude of about 2000 feet, August 8, 1921. Mulford Biological Exploration No. 649.

Dr. White says: "A small evergreen tree 20 to 30 feet high, trunk 6 inches in diameter, growing in damp, partly shady places near the river bank. The fruit is green with white specks, the cup brilliant scarlet-red. Not common."

Guarea Bangii Rusby, sp. nov.

Only fruiting specimens seen. Glabrous, with the exception of the tomentose fruit, pedicels and peduncles, and a very slight short, sparse pubescence on the leaf rachis, petiolules and lower surface of the midribs. Rachis and petiole subterete, slender, together 7–20 cm. long, the petiole varying from one-eighth (in the larger leaves) to one-half (in the smaller ones) of the total length. Leaflets three to five pairs, opposite, the lower successively much smaller, 7–20 cm. long, including the petiolule, which is one-tenth to one-fifth of the total, 3–7 cm. wide, thin, pale green, oblanceolate, acute at the base, the summit very

abruptly contracted into a short and broad, mostly obtuse acumination, the margin entire and not revolute. Midrib usually slightly furrowed on its upper surface toward the base, underneath prominent and slender, like the seven to twelve pairs of mostly opposite secondaries, which are strongly upcurved near the margin, where they are obscurely confluent. Fruit-panicles much shorter than their leaves, sessile or subsessile, rather densely fruited, the rachis and pedicels very stout, the latter little longer than broad, annular-roughened, articulated with the very short stipe of the fruit, which is not so thick as its pedicel. Mature fruit usually a little more than 2 cm. long and nearly or quite as broad, pear-shaped when young, becoming nearly spherical, except for the narrow base, which remains unchanged to form a short thecaphore. Body of fruit obscurely costate or striate, tubercular-roughened and softly and finely tomentose.

First collected by Mr. Miguel Bang, on the hills near Tipuani. Collected also by H. H. Rusby in October, 1921, on the Mulford Biological Exploration, at Rurrenabaque, Bolivia, Nos. 779 and 1590; also No. 2178 ("Guapi B"). All the spurious cocillana bark that has reached our market up to the present has been derived from this species.

A good-sized forest tree of the Mapiri and Beni River region, growing mostly on the hillsides in relatively dry soil, the bark roughly striate and shreddy, and peeling in long, fibrous, thin strips.

Guarea alborosea Rusby, sp. nov.

Glabrous, the petiolule and lower surface of midrib finely verrucose or papillose in the dried state. Petiole and rachis rather stout, deep purple, together 2–4 dm. long, the petiole about one-fifth of the total length, flat on the upper surface, the leaflets five to ten pairs, nearly opposite, the lower somewhat smaller. Petiolules 4–8 mm. long, stout, lightly channeled above, like the midrib. Blades 10–20 cm. long, by 4–8 cm. wide, thickish, pale underneath, oval or slightly narrower either below or above the middle, the base rounded or obtuse, the summit very abruptly contracted into a short, narrow, acute point, the margin entire and not revolute, the venation not at all prominent above, sharply so underneath, the secondaries ten to fifteen on a side, not opposite, straight and slender, moderately spreading, falcate toward the margin, connected by the coarsely reticulate tertiaries. Inflorescence axillary, racemose, simple, or occasionally slightly branched at the base, the racemes recurved-pendulous, often 2–3 dm. long, 1.5–2 cm. broad, densely flowered, the rachis slender, strongly nodose by the flower-scars, the bractlets minute, the flowers divaricate. Pedicels slender, articulated

into the broad concave base, the pedicel proper scarcely one-fifth the length of the flower, obscurely angled. Unopened calyx not seen. Mature flowers about 6 mm. long, the erect unexpanded corolla 2.5–3 mm. broad. Calyx crateriform, 3 mm. broad, closely investing the base of the corolla, deeply four-lobed, the lobes thick, purple, broadly ovate and obtuse. Petals 6 mm. long, 2 mm. broad, oblong, obtuse, slightly thickened at the purple or rose colored summit, the basal portion white. Stamen-tube three-fourths the length of the petals, broadly sulcate, slightly contracted below the mouth, which is not quite so broad as the lower half, the margin shallowly eight-crenate, the small anthers equalling its lobes. Ovary and style appressed-pilose, the ovoid ovary about equalling the stout style in length, the latter reaching the summit of the tube. Immature fruit fig-shaped, abruptly contracted at the base, then tapering into the stout short pedicel. Mature fruit not seen.

A small tree in the forest at Rurrenabaque, Bolivia, at an altitude of about 1000 feet. Collected by H. H. Rusby in flower and fruit, on the Mulford Biological Exploration, October 6, 1921 (No. 797).

The species is peculiar in its very long slender raceme and in the handsome rose and white coloration of its flowers.

Notes on trees and shrubs of the southeastern United States

W. W. ASHE

1. THE CASTANEA PUMILA GROUP

Castanea pumila Margaretta var. nov.

A tree, sometimes attaining (in Arkansas) a height of 15 m. and a diameter of 1 m., but usually smaller and often a large single-stemmed shrub. Leaves sinuate-serrate with ten to twenty pairs of lateral veins; sun leaves, especially those on flowering twigs, oblong or lance-oblong, 8–15 cm. long, 3–5 cm. broad, acute and somewhat taper-pointed at each end, thick and firm, dark green above, close white-pubescent beneath except on the midrib and veins; shade leaves 5–12 cm. long, 3–6 cm. broad, obovate or sometimes oblong-obovate, obtuse, or rounded and abruptly pointed at the apex, cuneate at the base, thin, pale green on both sides, but more or less pubescent beneath. Staminate aments continuous, 8–12 cm. long, at anthesis 6–8 mm. thick; calyx lobes 3–4 mm. long, obtuse; involucre of fruit bur-like, 2–4 cm. thick, canescent, comparatively thinly beset with branched rigid canescent spines, 3–6 mm. long, which as a rule are not sufficiently dense to conceal completely the involucre. Nut short-ovate, 11–15 mm. long, 7–12 mm. thick, pointed at the tip, shining, blackish brown.

Dry soils or, at the upper edge of the longleaf pine lands of Texas and Louisiana, along the edges of sandy hummocks. The following collections have been made by the writer: ALABAMA, Winston County; MISSISSIPPI, Jackson; LOUISIANA, Natchitoches and Sabine (TYPE) Parishes; TEXAS, Sabine County; OKLAHOMA, McCurtain County; and ARKANSAS, common on the mountains. Named for Margaret Henry Newland.

This variety largely replaces the typical *C. pumila* (L.) Mill. west and southwest of Tennessee and is separated from it by having the much shorter and smaller shade leaves of an obovate outline, thinner and often green beneath; by the closer white pubescence on the narrow and acute sun leaves (never velvety and rarely dull grayish); by the spines of the involucre being canescent well toward their tips (those of the typical *C. pumila* being nearly glabrous when mature) and seldom so dense as to conceal the involucre. Nut apparently not quite so plump as that of the type.

CASTANEA ALNIFOLIA Nutt.

The western recorded limit of this dwarf shrub with its subterraneous stems is Louisiana.* It was collected by the writer in Newton County, Texas, during October, 1921, under the same conditions as it grows further east and not exceeding 18 inches in height. *C. alnifolia pubescens* Nutt. has all of the leaves pubescent beneath.

Castanea floridana (Sarg.) comb nov.

Castanea alnifolia floridana Sarg. Bot. Gaz. **67**: 242. 1919.

I have not seen authentic specimens of the tree which Dr. Sargent has recently described and which he separates from the typical *C. alnifolia* by its arborescent form, but it is believed that material collected near Charleston, South Carolina, in 1915 represents it; and, if so, the differences of smaller fruit (which is more densely hispid), somewhat larger leaves with about two more pairs of lateral veins, and entirely different habit of growth justify specific rank.

× CASTANEA NEGLECTA Dode, Bull. Soc. Dendr. France **8**: 155. May, 1908. *C. pumila* × *C. dentata*

According to the description this hybrid is in general like *C. pumila*. It differs, however, in having larger and less densely pubescent leaves, a larger involucre with irregular spines, longer aments, and a single larger nut. The distribution is given as extending from Maryland to North Carolina. As a rule hybrids between *C. pumila* and *C. dentata* have the nuts in pairs, although this is not necessarily the case.

M. Dode has been kind enough to furnish the writer with a list of the specimens at the Museum of Paris, which he refers to *C. neglecta*. Of the seven specimens listed, the locations of five are well within the ranges of both *C. pumila* and *C. dentata*. These are: *Small & Heller 152*, and their collection of June 22, 1891, both from Blowing Rock, North Carolina; *Pearson*, Fairfax County, Virginia, 1844; *Green*, Maryland, 1839; *Bonpland*, Washington, D. C. Since the states only are given for the other two (*Gibbs*, South Carolina, and *Vasey*, Alabama, 1878), it is not possible to determine this.

* Small, Flora S. E. U. S. Ed. 2, 348.

Material collected by the writer in the mountains of Rabun County, Georgia, and Yancey County, North Carolina, largely agrees with Dode's description of *C. neglecta*. In its gross characters it shows, as Dode states, a superficial resemblance to *C. dentata*, having large pointed leaves, not very densely pubescent, and a large involucre with long, irregular, nearly glabrous and closely crowded spines; but there are two nuts to the involucre. Other material collected in flower in Sullivan County, Tennessee, shows similar leaf character.

Castanea Ashei Sudworth, comb. nov.

Castanea pumila Ashei Sudworth, Am. For. **28**: 300. 1922.

This is the common chinquepin of the coastal plain of the Southern States. Its distribution begins in northeastern North Carolina and extends to Louisiana (and probably to southeastern Texas). It is separated from *C. pumila* by its smaller foliage, shorter and more slender aments, canescent spines on the involucre and prevailingly thicker nuts. Walter (Fl. Car. 233. 1788) notes two forms (without description), *praecox* and *serotina*. *C. Ashei* is possibly his forma *praecox*.

The type of *C. pumila* (L.) Mill. (*Fagus pumila* L.) came from eastern Virginia (Gronovius, Flora Virginica 118. 1739), within which region the only known form is that which is here regarded as typical *C. pumila*.

Key to Castanea pumila group (one nut to the involucre)

Al=Alleghanian; C=Carolinian; A=Austral.

Spines of mature fruit densely set, glabrous or glabrate.
- Leaves soft-pubescent beneath .... *C. pumila* (Al & C).
- Leaves 10–20 cm. long, more or less glabrate.. × *C. neglecta* (Al).

Spines of mature fruit not densely set, canescent or tips merely glabrate.
- Leaves 10–15 cm. long; 12–20 pairs of veins.
  - All leaves closely white-pubescent beneath.......................... *C. Ashei* (A).
  - Interior leaves green beneath or glabrate......................... *C. pumila Margaretta* (C).
- Leaves 6–10 cm. long; 8–16 pairs of veins.
  - Only uppermost leaves on twigs white-pubescent beneath.
    - 10–16 pairs of veins, non-stoloniferous. *C. floridana* (A).
    - 8–12 pairs of veins, a dwarf stoloniferous shrub.......................... *C. alnifolia* (A).
  - All leaves white pubescent beneath...... *C. alnifolia pubescens* (A).

2. MISCELLANEOUS SPECIES

× **Quercus coloradensis** hybr. nov. *Q. virginiana* Mill. × *Q. macrocarpa* Mx.

Leaves heterophyllous, entire and oblong or undulate, sinuate or lobed, especially near the apex, with short abruptly acute or obtuse lobes, 4.5–10 cm. long, 2–4 cm. wide, thick and subcoriaceous, dark green above, strongly reticulated and densely close white-pubescent beneath, revolute on the margins; twigs 3–4 mm. thick, permanently close pale gray pubescent. Fruit 2.5–3 mm. long, excluding peduncle (which is often of half the length of the fruit); cup covering one-half or more of the oblong nut, obconic or slightly rounded, covered with slender acute, closely imbricate scales, either thin at the top or much thickened by several overlapping rows of scales and incurved at the edge.

Along the Colorado River above Marble Falls, Texas. While the overcup oak is rare in this region, the cup-character points to that species rather than to *Q. acuminata* Houba or *Q. stellata* Wang. as a possible parent.

Quercus nigra elongata comb. nov.

Quercus aquatica elongata Ait. Hort. Kew. ed. 1, **3**: 357. 1789.

In the third edition of Aiton's work there is a reference to a plate (Abbott, Insects Ga. 2: *pl. 29.*), which figures the leaf-form described by Sargent under his *Q. nigra tridentifera* (Bot. Gaz. **65**: 429. 1918).

Malus elongata pubens var. nov.

In general similar to the type but having somewhat broader leaves, permanently soft-pubescent beneath

Head of Chattoga River, Rabun County, Georgia, October, 1913, *W. W. A.*

Malus platycarpa parvula var. nov.

Foliage in general similar to that of type, but the leaves more ovate in outline and smaller; fruit of the same shape but much smaller, no larger than that of *M. elongata.*

Habersham County, Georgia, October, 1913, *W. W. A.*

Commelinantia, a new genus of the Commelinaceae

B. C. THARP

(WITH PLATES 10 AND 11)

Few if any families of plants have members in more urgent need of field study than are those of the family Commelinaceae. Their evanescent corollas, which it is difficult even to bring from field to laboratory without injury; the delicate shades of color which are lost in pressing; and their succulent stems, which shrink tremendously in drying, make field study imperative if one is to get any adequate idea of these delicate details as they appear in the growing plants. Since 1919 I have had abundant opportunity for field study of a very interesting member of the family, a species first described by Torrey* as *Tradescantia anomala* and latter transferred by C. B. Clarke† to the genus *Tinantia*, where it has remained to the present time.

Torrey's description, based upon specimens from Texas, (one of Wright's, and one of Thurber's), preserved in the herbarium of the New York Botanical Garden, is surprisingly good, considering that it was drawn wholly from dried material. Such details of general habit, sepals, petals (except color), filaments (except that of the posterior stamen), anthers, style, stigma, and ovules, as are pointed out, are correctly described. The greatest error into which his material led him seems to have been in considering the ovary and capsule two-celled. He also described the seeds as being "as in the rest of the genus," which is incorrect. The wonder is that, having examined his material so carefully as to be able to write such an accurate description, he could feel justified in assigning this species to the genus *Tradescantia*. That he was none too confident of its having been correctly assigned is abundantly testified by the specific name, by legends‡ on the sheets containing his specimens, and by his

* U. S. and Mex. Bound. Bot. 225. 1859.

† DeCandolle, Monog. Phaner. **3**: 287, 1881.

‡ Wright's specimen is labelled "Wright, Texas, *Commelyna anomala*, Torr. *Tradescantia anomala* Torr.," the word "*Commelyna*" being stricken out. Thurber's specimen is labelled "Thurber, San Antonio Texas, May 1853. *Commelyna rhodantha*, Torr."

observation that "the species is intermediate between *Tradescantia* and *Commelyna*."

Clarke's description of *Tinantia anomala* appears to be based neither upon the excellent original by Torrey, nor upon any critical examination of material of the species. He characterizes the plant as glabrous, the leaves as ovate-cordate, the three longer stamens simply as "naked above," the three shorter as having "golden bearded anthers," the stems as "dichotomously branched," the inflorescence as being "almost included in the subcomplicate uppermost leaf," the petals as being "obovate-elliptic, bluish" (by inference all alike in size and appearance). With the exception of the capsule, the measurements of all structures are under-stated. His specimens may not have shown the basal linear-lanceolate, ciliate, leaves; his scant measurements may have been due to his materials having shrunken in drying, and his representation of the "uppermost leaf" as "subcomplicate" may have been due to his specimens having been somewhat wilted before being pressed; but there seems no valid excuse for so inaccurate a description of stamens, or for characterizing the stems as dichotomously branched, or for totally ignoring the description (excellent so far as it goes) of Torrey. His observation, concerning the relationship existing between the type species (*T. fugax*) and the other species, that "caeterae species . . . cum *T. fugace* . . . militant; et ad *Tinantiam* ex necessitate referendae sunt, nisi genus *Tinantia* ad *Tradescantiam* reducatur," seems to be in the nature of an apologetic attempt at justification, though it is difficult to see the logic in his statement.

My own experience with an abundance of fresh material of the species in question constrains me to call attention to the following characteristics, which keep it from being properly placed in the genus *Tinantia* as characterized by Clarke: branches which break through the leaf sheaths; flowers in a simple terminal scorpioid raceme subtended by a *single, broad, erect, flat, cordate, clasping spathe*; colored lateral petals much larger than the very small anterior white petal; stamens of four distinct kinds as regards size and pubescence.

The character of the stamens and of the spathe and the habit of the branches breaking through the leaf sheaths are sufficient to exclude it from either *Commelina* or *Tradescantia*. The former has difformed stamens, all of whose filaments are entirely

glabrous and some of whose anthers are sterile; a spathe which is folded so as to protect alike the flowers bud and the ripening capsule, the flower being projected above the edges of the spathe only during the very brief period of bloom: the latter has stamens all alike in size and pubescence and all fertile; the inflorescence subtended by one or more (usually two) unlike bracts, never by a spathe. Neither *Commelina* nor *Tradescantia* has branches which break through the leaf sheaths. This habit, however, is held in common with certain tropical genera to which the species has never been heretofore compared. Dr. Pennell has kindly gone over the whole family as represented by specimens in the New York Botanical Garden Herbarium and reports the following genera as having this habit:

1. *Callisia* (tropical American) lacks spathe, has uniform petals and stamens.
2. *Campelia* (tropical American) has spathe, but uniform petals and stamens, white.
3. *Cyanotis* (tropical Asia) has series of overlapping spathes.
4. *Dichorisandra* (tropical American) lacks spathe, inflorescence a panicle.
5. *Floscopa* (tropical American and Asia) lacks spathe, inflorescence a panicle.
6. *Forrestia* (tropical Asia) lacks spathe, inflorescence congested erupts spathe.
7. *Pollia* (tropical Asia) lacks spathe, inflorescence a panicle.
8. *Sauvellea* (Cuba) has spathe, but petals and stamens uniform; repent.
9. *Streptolirion* (China) has spathe below cymes or panicle, but petals and stamens uniform, the filaments bearded. Stem twining.
10. *Tradescantella* (Florida) lacks spathe, but petals and stamens uniform. Repent.
11. *Zebrina* (tropical American) has two bracts below the congested inflorescence; petals uniform, at base approximating to form a corolla-tube. Repent.

The species differs from any of these generic groups in its combination of erect habit, single, flat, erect, spathe; unequal petals; and stamens of four forms.

In addition to the several genera listed above, Dr. Pennell finds that *Tradescantia Pringlei* S. Wats.* also has leaves which break through the sheathes. Moreover, it has the following additional characters which ally it very closely to *T. anomala*: general appearance very similar; inflorescence a simple scorpoid raceme (or frequently reduced to only one flower); stamens probably like those of *T. anomala* in that there are four kinds,

*Trans. Am. Acad. **26**: 157. 1891.

implied by the following statement: "stamens 6, unequal, the longer with filiform filaments bearded in the middle (or one naked) and broadly oblong anthers, the shorter filaments densely bearded in the middle with green gland-tipped hairs, the anthers orbicular; anther cells contiguous." The stamen corresponding to the posterior stamen in *T. anomala* might, by casual examination, have been counted as being like the postero-lateral ones.

But *T. Pringlei* has the following characters in conflict with *T. anomala*: plant green, not glaucous; cauline leaves uniformly ovate, abruptly acuminate, none modified to form a definite "spathe" (though the slender peduncles of *T. Pringlei* frequently have one or more much reduced sheathes below the inflorescence), inflorescence axillary, petals uniform, all blue ("purple" ?). Though *T. Pringlei* thus shows such strong resemblance to *T. anomala* in certain characteristics, yet because of these important points of dissimilarity and because of insufficient material for critical study I feel constrained to be content with pointing to it as perhaps the closest existing relative of *T. anomala*, leaving the question of its assignment to the proper genus to be settled by a more critical study of more abundant material. Certainly it can not properly belong in the genus *Tradescantia*!

Confining my attention, therefore, in the present paper to the placing of *T. anomala*, it seems not only justifiable but necessary to make it the type of a new genus.* Following the suggestion of Torrey that the species has certain characteristics which ally it to *Tradescantia* and *Commelina* and recognizing the fact that it was assigned to *Tinantia* more than forty years ago, I propose a sort of hybridization of these names, giving the new genus the name *Commelinantia*. The generic description which follows is made broad enough to include some of the distinctive characters of *T. Pringlei*, acting on the probability that this species will ultimately be assigned to the new genus.

COMMELINANTIA gen nov.

Annual succulent plants, somewhat resembling species of *Commelina*: stems 2–8 dm. long, erect, ascending, or decumbent.

* Since I began the study of this species with the view of determining the propriety of retaining it in *Tinantia*, I have learned that Dr. J. K. Small had decided to segregate it as a distinct genus in the next edition of his Flora of the Southeastern United States.

glabrous, much branched at maturity, the branches ascending, breaking through the close-fitting leaf-sheaths: *basal leaves* 0.5–3.5 dm. long, acute or acuminate, smooth or slightly pubescent with a few long hairs, appearing in early winter after the fall rain; *lower cauline leaves* resembling the basal leaves, 0.5–2.5 dm. long, the petiole arising from the closed sheath; *upper cauline leaves* generally shorter and broader than the lower; *inflorescence* a simple scorpoid, peduncled raceme, terminating branches and stems (or sometimes axillary and reduced to a single flower); *flowers* one or more (usually), each subtended by a small ovate bract; *calyx* of three similar, green, ovate, imbricated, persistent sepals; *corolla* showy, the petals equal or very unequal; *stamens* six, all fertile but dissimilar in size and in degree of pubescence; *ovary* oblong, three-celled, with two superimposed ovules in each cell, the stigma capitate; *capsule* loculicidally three-valved, the seeds greyish brown with copious endosperm surrounding the transverse embryo.

Commelinantia anomala (Torr.) comb. nov.

Tradescantia anomala Torr. U. S. & Mex. Bound. Bot. 225. 1859.

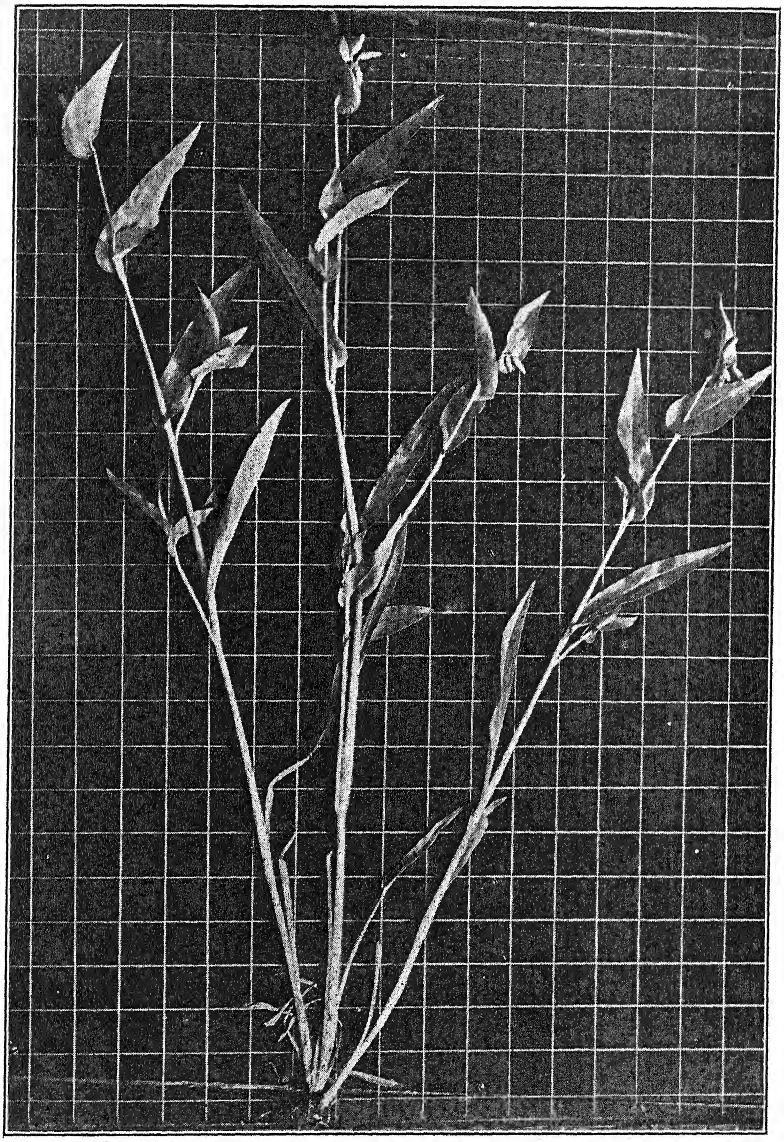
Tinantia anomala C. B. Clarke; De Candolle, Monog, Phaner. **3**: 287. 1881.

Pea green, usually glaucescent throughout: *stems* clustered, at first simple but later much branched, more than one branch frequently arising at a single node (especially in the upper part of a stem late in the season); *basal leaves* 2–3.5 dm. long, linear-spatulate, attenuate into long ciliate petioles below, rather pale green, glaucescent, slightly pubescent with a few long hairs above; *lower cauline leaves* 1.5–2.5 dm. long; *upper cauline leaves* sessile at the top of the sheaths or short-petioled, 0.5–2 dm. long, broadly or narrowly lanceolate or somewhat cordate and clasping at the base, acute or acuminate; *inflorescence* strictly terminal on stems and branches, subtended by a spathe strongly resembling the upper cauline leaves except in being erect, shorter (4–8 cm. long), broader, and strongly cordate-clasping at the base and in having no sheath; *flowers* three to sixteen or more, the bracts persistent, glabrous and green, each usually 3–5 mm. long; *sepals* keeled, slightly hooded, blunt, 9–12 mm. long, glandular-ciliate above the middle in the bud, a few apical cilia being persistent; *corolla* of two postero-lateral very showy lavender blue petals and a very small and in conspicuous anterior white petal, the showy petals almost rhomboid, 1.5–1.8 cm. long and somewhat broader than long, the small petal ovate-rhomboid, 3–4 mm. long, and longer than broad; *stamens* with filaments, of four distinct forms— (*a*) the posterior stamen densely bearded (except at the extreme apex, at the

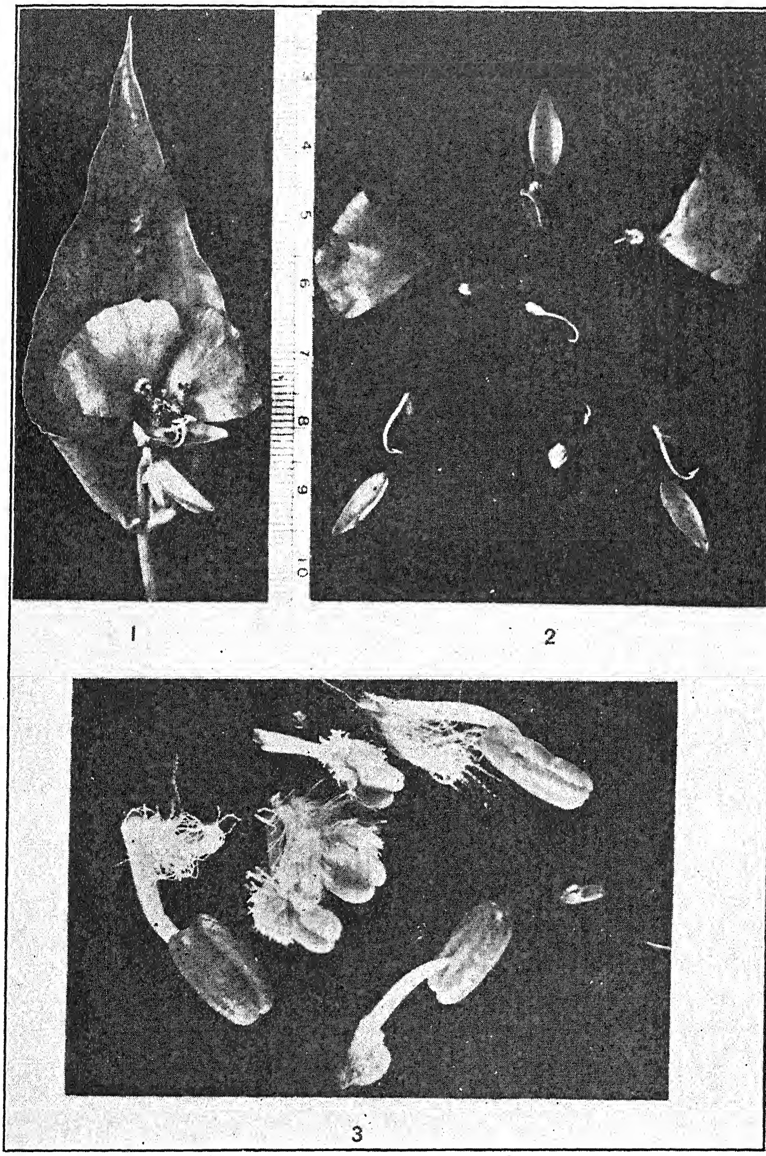
extreme base and in the lower two-thirds of the inner face) with showy lavender-purple hairs, (*b*) the two postero-lateral densely bearded above the middle with a collar of short lavender-purple yellow-tipped hairs, (*c*) the two antero-lateral bearded below the middle on the posterior margin with a tuft of short lavender hairs, and (*d*) the anterior stamen glabrous throughout—anthers of the three anterior stamens oblong, these stamens being manifestly larger throughout than the posterior stamens, the latter with orbicular anthers; *ovary* constricted in the middle, the stigma terminating a slender bent white style; *capsule* oblong, 6–8 mm. long; *seeds* 3–3.5 x 2–2.25 mm., rounded at one end, truncate at the other, with a curved longitudinal grooved hilum on the inner face, near the center of which lies an apparent eccentric perforation containing the minute embryo; *endosperm* not continuous but separated by an obscure commissure on one side and bearing a group of low broad, tuberculate ridges radiating from the sides of the embryo cavity, where it comes through to the outer surface.

In rich, moist, shaded soil of ravines and rocky hillsides of the Edwards Plateau, Texas; February to October, but principally March to May. Original localities, according to Torrey: "shady woods on the Blanco, Comale, and other rivers, Texas; *Wright*, (No. 699.) San Antonio, Texas; *Thurber*."

A comparison of Torrey's description with that submitted herewith will reveal several places wherein certain differences appear. These differences are: (1) in the height of the plant; (2) length of basal leaves; (3) number of flowers per raceme; (4) I can find no evidence of wings on the margin of the posterior filament and am at a loss to account for Torrey's mention of such structures unless he examined the filament in question only from the flat naked inner face of pressed material; (5) the ovary is uniformly three-celled with two superimposed ovules in each cavity, though failure of fertilization will of course cause abortion of any one or more of the six, with a consequent great variation in the appearance of the capsule; (6) the seeds, though superficially resembling those of *Tradescantia*, are different from any *Tradescantia* seeds I have examined in that the cavity containing the embryo extends entirely through the seed, the endosperm instead of being continuous around the embryo is separated by a commissure that extends to the embryo-cavity on one side, and the seeds of *C. anomala* are of greater size. Other points which are brought out in the description submitted herewith are not mentioned in that of Torrey.



COMMELINANTIA ANOMALA (TORR.) THARP



COMMELINANTIA ANOMALA (Torr.) Tharp

I am indebted to Dr. F. W. Pennell, now of the Philadelphia Academy of Sciences, for helpful criticism and advice, for assistance in looking up the literature, and for access to a specimen of *Tinantia Pringlei*.

UNIVERSITY OF TEXAS.

Explanation of plates 10 and 11

PLATE 10

Plant of *Commelinantia anomala* (Torr.) Tharp, showing typical appearance of a flourishing specimen in bloom. The specimen is somewhat wilted causing the spathe to fold slightly. The linear-spatulate basal leaves, characteristic of plants during winter months, have disappeared by the time the stems have reached this stage of maturity. Scorpoid racemes seen in profile. Scale in inches.

PLATE 11

FIG. 1. Inflorescence of *C. anomala*, showing the position assumed by each flower as it comes into bloom. The spathe is somewhat wilted, causing it to roll slightly at the edges. Scale metric.

FIG. 2. Dissected flower to show relative size and general appearance of parts.

FIG. 3. Stamens from a bud several hours before anthesis; magnified eight diameters. The filaments have not attained nearly the length of those in an open flower, but the anthers are beginning to dehisce. Relative size and shape of mature anthers, and also the nature of the pubescence of filaments well shown.

INDEX TO AMERICAN BOTANICAL LITERATURE
1912–1922

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to foresty, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Vol 49. No. 10

BULLETIN

OF THE

TORREY BOTANICAL CLUB

OCTOBER, 1922

The genus Costus in Central America

W. W. Rowlee

(WITH PLATES 12–15)

As at present organized the genus *Costus* L. is composed of about one hundred species, divided almost equally between the Eastern and Western Hemispheres. Very few species occur in both hemispheres. The American species are most abundant in regions of heavy rainfall, maximum humidity and high temperature of both air and soil. The genus ranges from one Tropic to the other; it occurs wherever conditions are favorable in hot, warm and temperate regions, but is not found in high and cold districts.

In any given locality the species do not usually appear abundant, but are scattered about in deep woodlands and undisturbed jungle. The plants are herbaceous perennials with spirally arranged leaves. The stems or culms are simple and represent branches arising from a system of underground rootstocks. They thus form gregarious clusters, some of the culms remaining sterile and others producing spikes of flowers. In some cases the mats are more extensive than in others, this depending partly upon age and partly upon the habit of the plant. The leaves are ovate to lanceolate in outline and invariably entire.

In Spanish American countries members of the genus are called "canagria" or "cana agria," meaning "bitter cane,"

[The Bulletin for September (49: 259–282. *pl. 10, 11*) was issued September 22, 1922.]

all jointed and unbranched stems being known as "cana" and the tissues in the present instance being very bitter. The plants are fleshy throughout their whole body structure, and their tissues are saturated with water, so that it is difficult to make satisfactory herbarium specimens. Certain parts of the plant and especially the spikes are so saturated as they grow in the field that it is easy to wring water from them. In drying they change their form markedly, and it is therefore most desirable to make observations on specimens growing under natural conditions. The flowers in many cases are delicately colored and become fragile when pressed.

The genus *Costus*, together with two or three other genera, belongs in the subfamily Costoideae of the family Zingiberaceae, the group being very distinct in its general characteristics from the other genera of the family. Two types have been recognized in the genus: in the first the floral spike is borne upon what may be called a normal leafy culm; in the second the floral spike develops upon a modified culm. In the first type the culms are designated as "not diverse;" in the second, as "diverse."

The species heretofore recorded from the Western Continent outside of South America have all belonged to the group in which the culms are not diverse. In the present paper two Central American species with diverse culms are reported and proposed as new. They are not closely related to each other, but each is represented by allied species in South America. The paper reports in addition an undescribed species from Central America in which the culms are not diverse and discusses the previously described Central American species.

Key to the Central American species

A. Culms diverse, the spikes borne on short bracteate scapes.
  B. Bracts of spikes with foliaceous appendages (Costa Rica)............................ 1. *C. bracteatus*
  BB. Bracts of spikes not appendiculate (Guatemala).................................. 2. *C. sepacuitensis.*
AA. Culms not diverse, the spikes borne on ordinary leafy ones.
  B. Bracts of spikes with foliaceous appendages.
    C. Spikes ovoid, green.
      D. Plants large, 2–3 m. tall; leaves about 30 cm. long, fuscous-hirsute, especially on the sheaths (Panama). 3. *C. villosissimus.*

DD. Plants small; leaves about 16 cm. long (Mexico, Costa Rica and Panama)........................... 4. *C. hirsutus.*
CC. Spikes cylindrical, red.
D. Appendages of bracts lanceolate, acuminate, upper sterile erect; leaves glabrous (Guatemala and Costa Rica).......................... 5. *C. Bakeri.*
DD. Appendages of bracts broadly ovate; leaves scabrous (Costa Rica) ...... 6. *C. lima.*
BB. Bracts of spikes not appendiculate.
C. Callose lacking on back of bracts (Costa Rica)........................... 7. *C. Malortieanus.*
CC. Callose present on back of bracts.
D. Spike ovoid; leaves sessile (Mexico). 8. *C. pulverulentus.*
DD. Spike fusiform (Costa Rica and Guatemala)..................... 9. *C. sanguineus.*
DDD. Spike cylindrical or spherical.
E. Plants small, about 2 m. high.
F. Leaves glabrous.
G. Spike red, cylindrical (Costa Rica and Panama) 10. *C. spicatus.*
GG. Spike green, spherical (Guatemala).......... 11. *C. congestus.*
FF. Leaves hairy beneath (Costa Rica and Panama)....... 12. *C. nutans.*
EE. Plant large, much more than 2 m. high.
F. Labellum orange-red with yellow markings (Costa Rica and Guatemala).......... 13. *C. splendens.*
FF. Labellum yellow (Costa Rica).................. 14. *C. laxus.*

1. **Costus bracteatus** sp. nov.

Plant clothed with long black hairs; leafy culms up to 2 m. high, the lower leaves reduced to sheathing scales; flowering culms 40 cm. tall, the leaves reduced to sheaths except the four or five uppermost, which bear small blades and closely surround the spike. Uppermost leaves on the sterile culms large and thin, 32 cm. long, 7 cm. wide, oblanceolate, acuminate at the apex and tapering below evenly to an acute base, ferruginous, hairy on both sides, the hairs arising from a bulbous base; midrib slender; venation 3.5/23;* petioles 1 cm. long, densely ferruginous-tomentose; ligules 5–10 mm. long, tomentose; sheaths

* This fraction indicates that there are 3.5 primary and 23 secondary veins to the centimeter.

overlapping, spreading-hirsute where exposed and with long appressed needle-like hairs where included in the next lower sheath: lower leaves reduced to sheaths with oblique orifices: sheaths of the flowering culms particularly loose, the uppermost leaves forming a transition to the bracts of the spike. Spike ovate-cylindrical, 13 cm. long, 6 cm. wide, conspicuously bracteate, the bracts oblong, 2–5 cm. long, 1–8 cm. wide, puberulent on the back and along the margins, strigillose within; appendages of the bracts narrowed at the base, ovate, acuminate, rusty puberulent: bracteole on the right side of the flower, conduplicate, 2.5 cm. long, with a linear callose 4 cm. long on the back near the apex, acuminate, rusty-puberulent. Flower 3.5 cm. long; ovary 5 cm. long, three-ribbed, the ribs densely tomentose, the facies less so: calyx 1.3 cm. long, rusty-puberulent, the lobes equal, triangular, 0.3 cm. long, acute: corolla three-lobed, very thin and delicate, nearly equalling the labellum, nearly as broad as long, reddish orange in the upper part: staminodia equalling the labellum, also reddish orange at the tip; stigma spoon-shaped with a notched appendage on the back. [PLATE 12.]

COSTA RICA: in woods on the hillside about a mile south of Siquirres, *H. E. Stork* (*Rowlee & Stork 675*). Specimen preserved in the herbarium of Cornell University.

Only a single mat of the species, including one flowering culm and several leafy culms, was found, although careful search was made for additional material. The plant differs from any other species known to us and is remarkable in its peculiar vesture and delicate texture. It appears to be most closely related to K. Schumann's *Costus Dinklagei* from Cameroon, Africa. The locality where this novelty was found is interesting. The old Spanish trail from the mouth of the Matina River leads westerly along the foot of the mountains to near Siquirres. It then ascends the mountains along the south side of the gorge of the Reventazon River to the central plateau, where the cities of Cartago and San Jose are located. Our plant was found near this trail. There was also found near the same place a spur (for horse-back riding) quite unlike any known to the present generation and probably dating back to the days of the buccaneer.

2. **Costus sepacuitensis** sp. nov.

Vegetative and fruiting culms diverse: leafy culms with large elliptic leaves (resembling those of *C. maximus*), at least 30 cm. long and 9 cm. wide, softly pubescent on both sides, margin ciliate; petiole 5 cm. long; ligule 1.5 cm. long, ciliate on the

margin, pubescent on upper part, glabrescent below; venation 5/25: flowering culm at least 30 cm. long, bearing only sheaths, the latter closely embracing the culm, sparsely puberulent. Spike not much exceeding the culm in thickness and appearing like it in texture and in color (dark chestnut in dried specimens): bracts broadly ovate, 4 cm. long, and 3 cm. wide, glabrous, highly polished especially within. Flowers not seen. Fruit obovoid, pubescent, 1.5 cm. long and 0.8 cm. wide, crowned with a deeply parted calyx; calyx lobes unequal, 1.3 cm. long, separated to near the base, ovate, acute. [PLATE 13.]

GUATEMALA: near the Finca Sepacuite, Alta Verapaz, April 13, 1902, *O. F. Cook & R. F. Griggs 596*. Known only from the type specimen, which is in the U. S. National Herbarium.

This remarkable plant is related to *C. geothyrsus* K. Schum. of Ecuador and *C. erythrocoryne* K. Schum. of Peru but differs from both in the shape and size of the spike, in the calyx, and in the vesture of the plant. Other species with diverse culms occur in South America and in the Eastern Hemisphere.

3. COSTUS VILLOSISSIMUS Jacq. Fragm. 51. *pl. 80*. 1800–1810

Specimens referable to this species from Central America and the West Indies exhibit considerable variation, although agreeing in stature and in having appendiculate green bracts and ovate spikes. The hairiness varies, for example, from tawny shagginess to an almost smooth condition, while the color of the flower varies from sulphur yellow to white. In all cases, however, the margin of the labellum is tinted with pink. The most typical specimen collected by H. E. Stork and the writer is No. 401, found in June, 1918, on the west side of the Panama Canal, opposite Balboa. The flowers are large and showy, the labellum being tubular, about 7.5 cm. and ivory white except for the rose red border. The whole plant and particularly the upper leaves are clothed with long tawny hairs. This specimen was 3 m. tall. Another specimen, also in bloom but only half as tall, is No. 325a, collected in September, 1918, at Quiriga, in Guatemala. It agrees with No. 401 in having tawny hairs and in the color of its flowers.

The species, although apparently rare, is widely distributed in tropical America. The following additional specimens from Central America may be cited: near Balboa, Canal Zone, Panama, *H. Pittier 3776, 3779, 6690;* Province of Alta Verapaz, Guatemala, *O. F. Cook & R. F. Griggs 308*.

4. COSTUS HIRSUTUS C. Presl, Reliq. Haenk. 1: 112. 1830

This is a much smaller plant than the foregoing, according to the writer's interpretation, and is evidently not more than 50 cm. high. The spike also is smaller. The following specimen seems to be characteristic: on the cattle trail between the Chiriqui Lagoon and the divide, western Panama, *H. E. Stork* (*Rowlee & Stork 1045*). Another specimen to be associated with the species is the following: upper stretch of the Saraquipi River, *H. Pittier 14166.* Both represent a diminutive *C. villosissimus.* The published descriptions of *C. hirsutus* are meager, and no drawing or photograph of the species has been seen by the writer.

5. COSTUS BAKERI K. Schum.; Engler, Pflanzenreich 4^{46}: 387. 1904

The following specimens of this species, all from the uplands of central and western Guatemala, have been studied: Barranca del Samalá, Dept. Retalhulen, 1700 ft. alt., *J. Donnell Smith 2801*; Barranca de Eminencia, Dept. Amatitlan, 1400 ft. alt., *J. Donnell Smith 2802* (Type); Volcan Tecuamburro, Dept. Santa Rosa, *J. Donnell Smith 4650.* The following specimen from central Costa Rica has likewise been examined: *A. Tonduz 282.*

C. Bakeri is characterized by having a cylindrical and appendiculate spike, more or less red in color; the appendages of the bracts being acute and longer than wide. In these respects it agrees with *C. comosus* (Jacq.) Roscoe, of northern Colombia and Venezuela, a species with which it was originally confused. In *C. comosus*, however, the upper surface of the leaves is softly hairy, while in *C. Bakeri* it is perfectly glabrous. It is probable that intermediates between these two species will be found.

6. COSTUS LIMA K. Schum.; Engler, Pflanzenreich 4^{46}: 388. 1904

Dr. Schumann apparently knew *C. lima* from the type specimen only, which was collected at the following station on the Pacific side of Costa Rica: near Punta Arenas, January, 1854, *Scherzer.* The species is frequent however, throughout the lowlands in the northern part of Costa Rica, being found also on the Atlantic side. The following additional specimens may be cited: Buenos Aires, near the continental divide, *A. Tonduz 6659;* Livingston on the Reventazon River, *Rowlee & Stork 648;* Siquirres, *Rowlee & Stork 1318.*

It agrees with *C. Bakeri* in having an appendiculate, cylindrical spike, often much shortened, but the color is more brilliantly red, making the spike very conspicuous. The appendages, moreover, differ in being shorter and less striking. The species is further characterized by the peculiar vesture of the very opaque leaves, the upper surface being clothed with shorter bulbous hairs, all pointing toward the apex, while the lower surface is densely covered by a tawny tomentum. The plants are large, often 5–7 m. high, and the spike is about the size of an ear of corn.

According to the original account *C. lima* is related to *C. Friedrichsenii* O. G. Peters., a species described from plants cultivated at Berlin. Dr. Schumann states that it was probably introduced from Central America, but the writer has seen no specimen agreeing with the description.

7. COSTUS MALORTIEANUS Wendl. Hamb. Garten- u. Blumenzeit. **19**: 30. 1863

So far as the writer's observations go *C. Malortieanus* is confined to the coastal plains of northeastern Costa Rica. The type locality is near the Sarapiqui River at the head of navigation, and the original description was drawn from specimens cultivated in Germany. The species grows also along the Reventazon River, where it emerges on to the lowlands. It is the gem of the genus. The plants are small, being less than 1 m. high, and grow in wide spreading mats, flowering in July and August. The flowers, which are not freely produced, are very beautiful, suggesting in their tints some of the tropical orchids. The leaves are broadly obovate, densely hairy, and obscurely variegated with darker and lighter threads of green. Specimens in the greenhouses of the New York Botanical Garden, although under cultivation for several years, have not as yet produced flowers.

Two other species of tropical North America with unappendaged bracts and no callose have been described under the names *C. pictus* D. Don, and *C. mexicanus* Liebm. Specimens of the first two have not been found by the writer, but both are apparently of Mexican origin, *C. pictus* being based on plants grown in England.

8. COSTUS PULVERULENTUS C. Presl, Reliq. Haenk. 1:41. 1830

The original specimen of *C. pulverulenus* was collected in Mexico by Haenke, no more definite locality being mentioned. The writer has identified with it, somewhat doubtfully, the following specimen from Guatemala, origina'ly referred to *C. Malortieanus*: Rio Sis, Dept. Suchitepequez, 1300 ft. alt., *J. Donnell Smith 2800.* This and the following six species agree in having a callose on the back of the bracts.

9. COSTUS SANGUINEUS Donn. Sm. Bot. Gaz. **31**: 122. 1901

This species is the most frequent representative of the genus in northern Costa Rica, and a photograph of it has been reproduced in Calvert's "A year of Costa Rican Natural History," opposite page 257, under the incorrect name *C. Malortieanus.* It is not found on the beach but inhabits higher ground, often at an elevation of as much as 2000 feet. The type specimen was collected in 1901, at Cubilquitz, Dept. Alta Verapaz, Guatemala, about 1000 ft. alt., by H. von Tuerckheim (No. 7686), but the species has been found in other Central American countries bounding the Carribbean Sea. The following specimens may be cited: Peralta, *Rowlee & Stork 45;* Livingston on the Reventazon River, *Rowlee & Stork 653;* and Siquirres, *Rowlee & Stork 1311, 1312.* The plant is about 1.5 m. high, and the leaves are softly pubescent. The red spikes are fusiform and acute, when perfectly developed, as shown in Calvert's figure, but they are frequently deformed and much shortened.

10. COSTUS SPICATUS (Jacq.) Sw. Prodr. Fl. Ind. Occ. 11. 1788

The original material of *C. spicatus* came from the West Indies, where the species is widely distributed. It is found, also, in the close vicinity of the seashore in northern Costa Rica, between Limon and the mouth of the Matina River. The following specimens may be referred to it: Chargres, 1850. *A. Fendler 446*; Rio Dulce, March, 1889, *J. Donnell Smith;* vicinity of Frio, province of Colon, August, 1911, *H. Pittier 4137;* Limon, *Rowlee & Stork 674.* The field notes that follow were made from No. 674.

Culms 1–2 m. high, many from a rather dense mat, leafy to near the base, whole plant glabrous. Leaves 18 cm. long, 7 cm. wide, elliptic, short-acuminate

at the apex, subauriculate at the base, shining green above, glacuous beneath, petioles 6 mm. long, sheath shorter than the internodes, ligule 5 mm. long, three or four leaves approximate to the base of the spike, venation 7735. Spike oblong, 7 cm. long, 2.3 cm. thick, very compact. Bracts nearly orbicular, 2.5–3 cm. in diameter. Bracteole 1.5 cm. long, relatively broad, boat-shaped, dextrad. Ovary 5 cm. long, glabrous, subtrigonous, seeds very numerous, angular with elater-like aril. Calyx 5 cm. long, campanulate and with very short broad lobes and red margins. Corolla orange-red, 2 cm. long, dilated at the apex, lobed to the middle, lobes oblong, acute. Labellum 3 cm. long, obovate, subtrilobed, yellow. Stamen 2.5 cm. long, lanceolate, obtuse, anther adnate above the middle.

11. **Costus congestus** sp. nov.

Stem less than 1 m. high. Leaves crowded near the summit; petioles 5 cm. long; blade 24 cm. long, 6 cm. wide, acuminate at the apex, tapering from above the middle toward the base, slightly glaucous beneath, green above, glabrous throughout. Spike spherical, about 4 cm. in length and breadth; lower bracts with leafy appendages; bract proper orbicular, red, with a callose line. Ovary glabrous, 4 mm. long; calyx divided to the base, the lobes unequal, oblong, rounded, at the apex; petals large, hyaline, obtuse; labellum 4 cm. long. [PLATE 14.]

GUATEMALA: Escuintla, 1100 ft. alt., March, 1890, *J. Donnell Smith 2036* (Type); Santa Lucia, Dept. Escuintla, 1045 ft. alt., March 3, 1905, *W. A. Kellerman 5284*; Santa Barbara, Dept. Solola, 1370 ft. alt., August, 1891, *J. Donnell Smith 137*. Type specimen in the herbarium of Cornell University.

MEXICO: vicinity of Choapam, Oaxaca, 3800–4500 ft. alt., July 28, 1894, *E. W. Nelson 911*.

The species is glabrous in all its parts. It differs from *C. spicatus* (Jacq.) Sw., to which Baker referred some of the specimens, in the size of the flower and in the shape and size of the spike.

12. COSTUS NUTANS K. Schum.; Engler, Pflanzenreich 4^{46}: 407. 1904

The type material of *C. nutans* came from the following locality: near Aguacate, Costa Rica, September, 1857 (in flower), *C. Hoffman 727*.

The only specimen seen by the writer was collected on Mount Pirri, Panama, on June 12, 1912, by E. A. Goldman (No. 1963) at an altitude of 1350 m. [PLATE 15.]

13. COSTUS SPLENDENS Donn. Sm. & Tuerckheim; Donnell Smith, Bot. Gaz. **33**: 260. 1902

Costus maximus K. Schum.; Engler, Pflanzenreich 4[46]: 405. 1904.
Costus giganteus Kuntze, Rev. Gen. 2: 687. 1891. Not Ridley, 1887.

The species was based on a specimen collected in Guatemala at an altitude of 350 m., by H. von Tuerckheim (No. 8015), no more definite locality being mentioned. The writer has not seen the type specimen, but other material collected in Guatemala by Von Tuerckheim and referred to *C. splendens* has been available for study. In this material the bracts bear a callose below the apex, although no structure of this sort is mentioned in the original description. Since these specimens are indistinguishable from *C. maximus* K. Schum., the name *C. splendens* will have to supplant the later name *C. maximus*, and the known range of the species will extend from Guatemala to Panama.

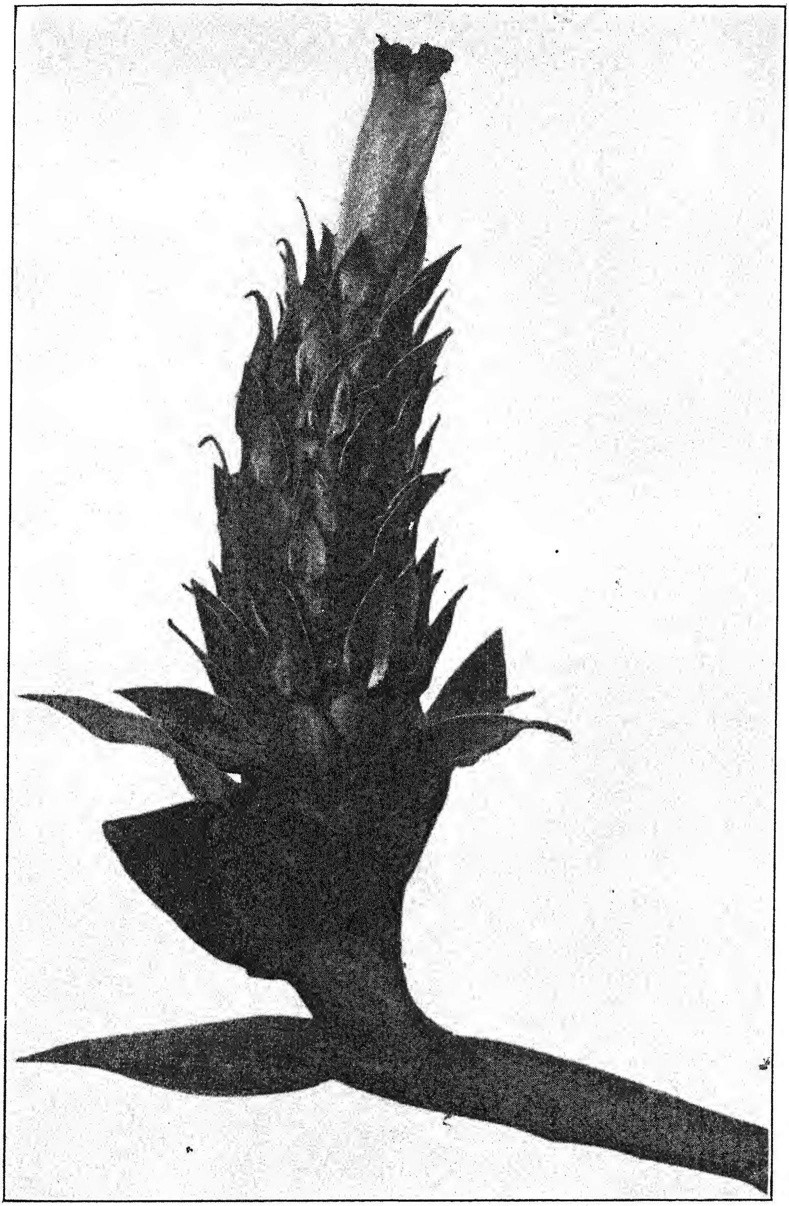
14. COSTUS LAXUS O. G. Peters.; Martius, Fl. Brasil. 3^3: 56. 1890

The type specimen was collected in Costa Rica by Aented in 1847, the name of the locality being illegible. The species is known also from Venezuela.

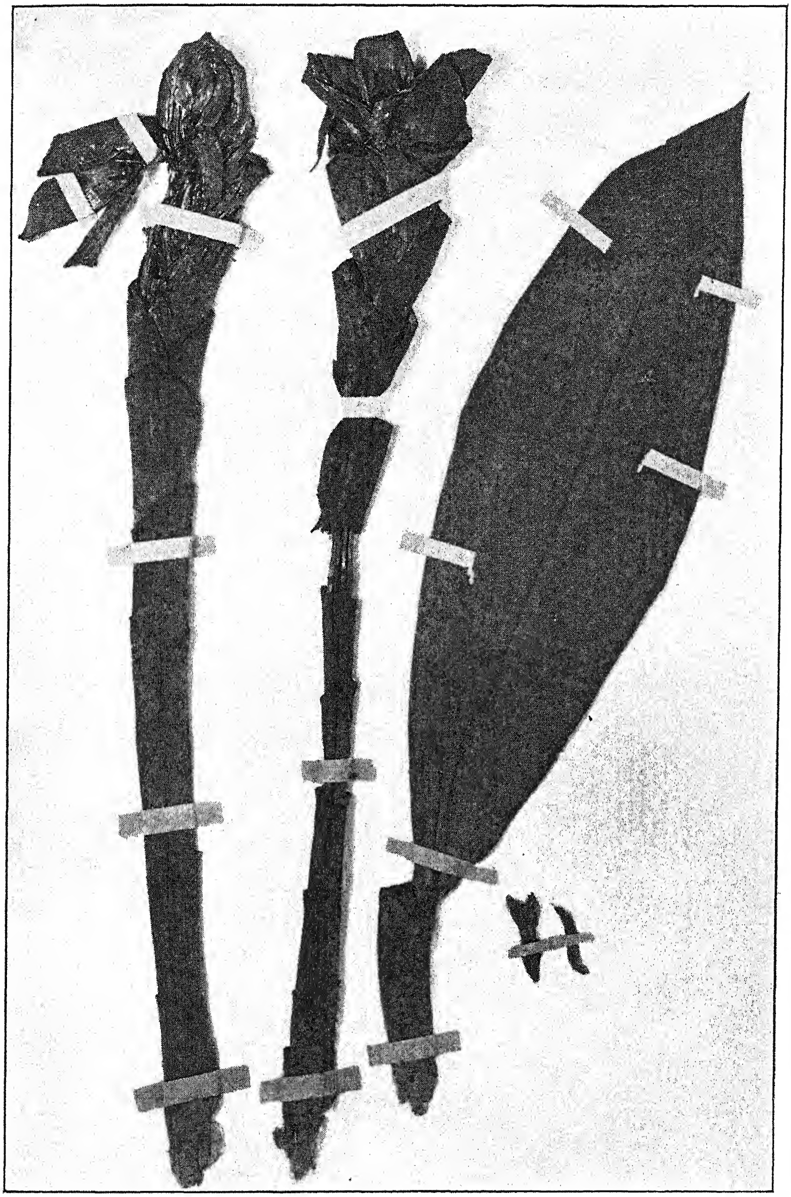
CORNELL UNIVERSITY

Explanation of plates 12-15

PLATE 12. COSTUS BRACTEATUS Rowlee.
PLATE 13. COSTUS SEPACUITENSIS Rowlee.
PLATE 14. COSTUS CONGESTUS Rowlee.
PLATE 15. COSTUS NUTANS K. Schum.

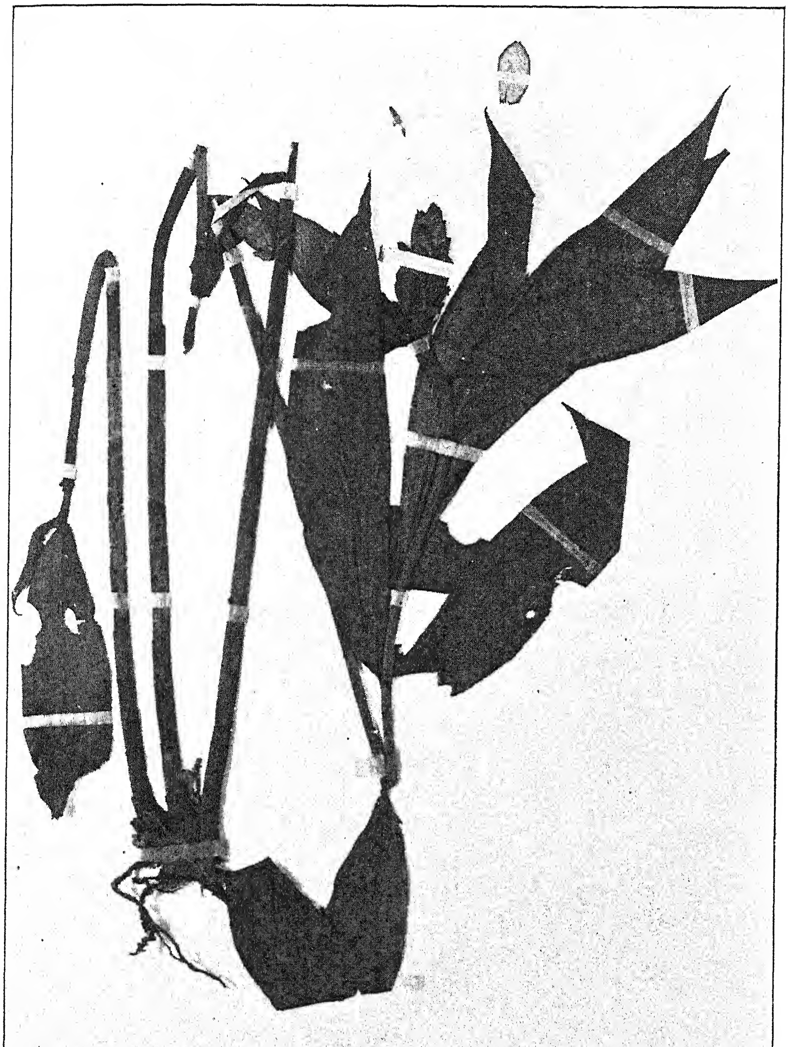


COSTUS BRACTEATUS ROWLEE



COSTUS SEPACUITENSIS ROWLEE

COSTUS CONGESTUS ROWLEE



COSTUS NUTANS K. SCHUM.

Quercus lyrata in Iowa

B. Shimek

(WITH PLATES 16 AND 17)

The discovery of the overcup oak, *Quercus lyrata* Walter, in Iowa, by the writer, so far extends the range of this species that it seems worthy of more detailed record. Sargent says* that the species "is distributed from the valley of the Patunxent River in southern Maryland southward near the coast to western Florida, through the Gulf States to the valley of the Trinity River in Texas, through Arkansas and southwestern Missouri, where in a swamp near Allentown, there is a single specimen, the most northern known representative of the species west of the Mississippi River, to central Tennessee, southern Indiana, and Jasper County, Illinois."

Other authors give the distribution less fully, but in all the references consulted the range falls within that here given. The herbarium of the Missouri Botanical Garden at St. Louis contains several specimens from the southern counties of Illinois, and from Butler County, Missouri, but these localities also lie within the territory given by Sargent.

The Iowa specimens are located in Iowa County, near the town of Amana. This not only extends the northern range west of the Mississippi, but the locality is more than two degrees of latitude north of the Maryland and Illinois localities, making this the northernmost point from which the species is known.

Thus far three trees have been found. They are located in the low bottom land timber along the Iowa River, the locality being subject to overflow and always quite moist. They are associated with the large, bottomland form of the bur oak, *Quercus macrocarpa*, a few trees of *Q. bicolor*, and the ordinary bottomland species of Iowa valleys, such as *Ulmus americana*, *Betula nigra*, *Populus deltoides*, *Acer saccharinum*, *A. Negundo*, *Platanus occidentalis*, and *Juglans nigra*. Other trees of the species will probably be found among the "bur-oaks."

The finest of the three specimens (shown in PLATE 16, FIG. 1) is about 70 feet high, and the trunk measures 22 inches in diameter at a height of 3 feet. Its rate of growth is probably approxi-

*Silva of North America **8**: 48. 1895.

mately the same as that of the large bottomland form of *Q. macrocarpa*, and a nearby specimen of the latter, recently cut, measured 27 inches in diameter and exhibited about 120 rings, those from about 55 to 85 showing the most rapid growth. Our overcup oak trees are probably not less than a hundred years old, thus antedating the coming of the white man to this section.

The trees have been observed both in flower and fruit. Sargent gives the time of flowering as March or April, but in this northern locality the flowers do not appear until about the middle of May.

Two of the trees produce acorns which are entirely enclosed in the cup; the third has a partly open cup, a form not infrequent in the South. The peduncles of the cups are 6–16 mm. in length. The wall of the cup is 3–6 mm. thick or even thicker at the base, but thins upward. The scales of the cup are prominently tubercular, the tubercles becoming smaller upward. The small opening has a short fringe.

The nut is short-ovate, with a broad basal scar and is 16–19 mm. in length, with about the same diameter. Its tops and sides are covered with a short, grayish pubescence. For cup and acorns see PLATE 16, FIG. 2.

The general aspect of the tree is not unlike that of the large form of *Q. macrocarpa* which grows in somewhat better drained spots in the same timber. The latter is here not gnarled or stunted, as is usually the case in more exposed localities. It is probable that our species has been mistaken for the latter in other localities.

The leaves are distinctly different from those of the nearby bur-oaks. As compared with the latter they are thinner, with more distinct veinlets; lighter green; more irregularly lobed, with the terminal lobe rarely coarsely crenate; usually smaller and narrower; and the upper surface is more likely to have scattered short hairs at maturity, while the pubescence of the lower surface is much less dense. PLATE 16, FIG. 3, shows young leaves, and PLATE 17 shows mature leaves taken in different years. The leaves and acorns shown on the plates are from the same tree.

On the whole the Iowa specimens of *Q. lyrata* are quite typical.

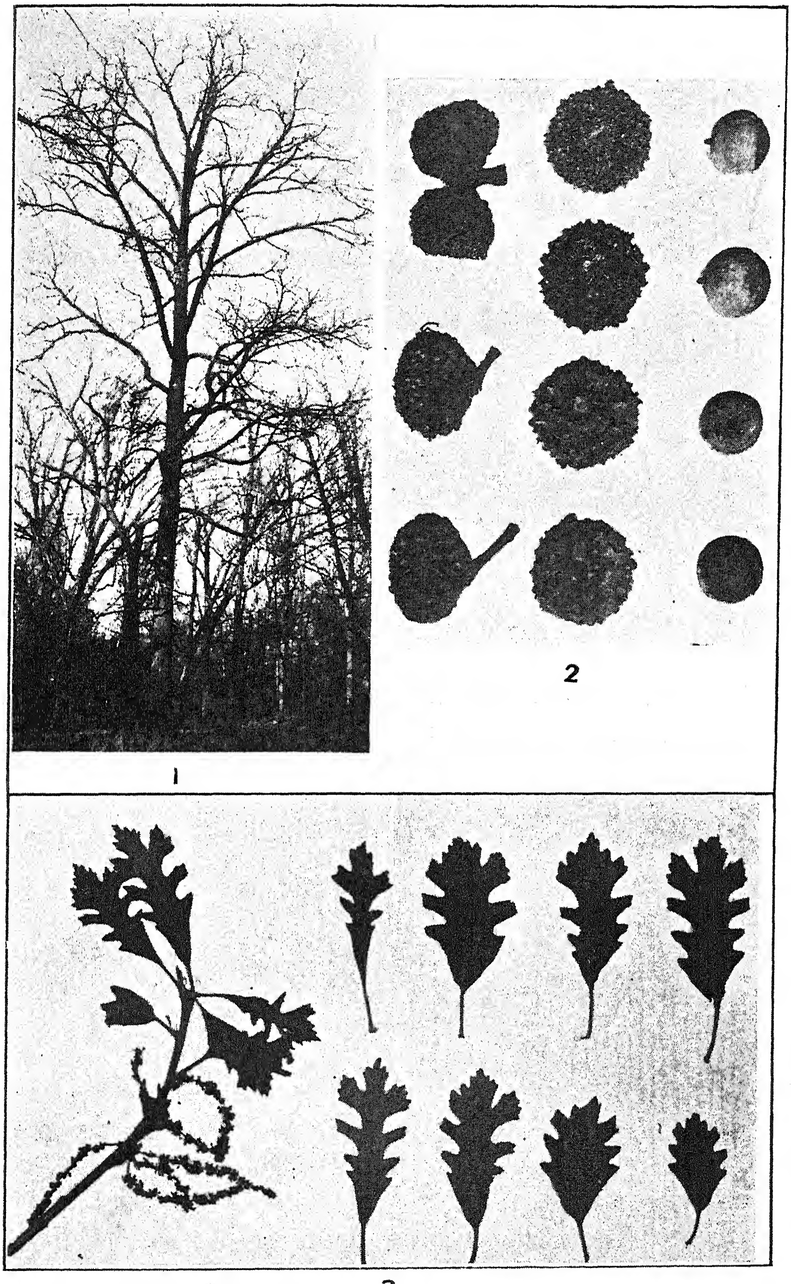
Explanation of plates 16 and 17

PLATE 16

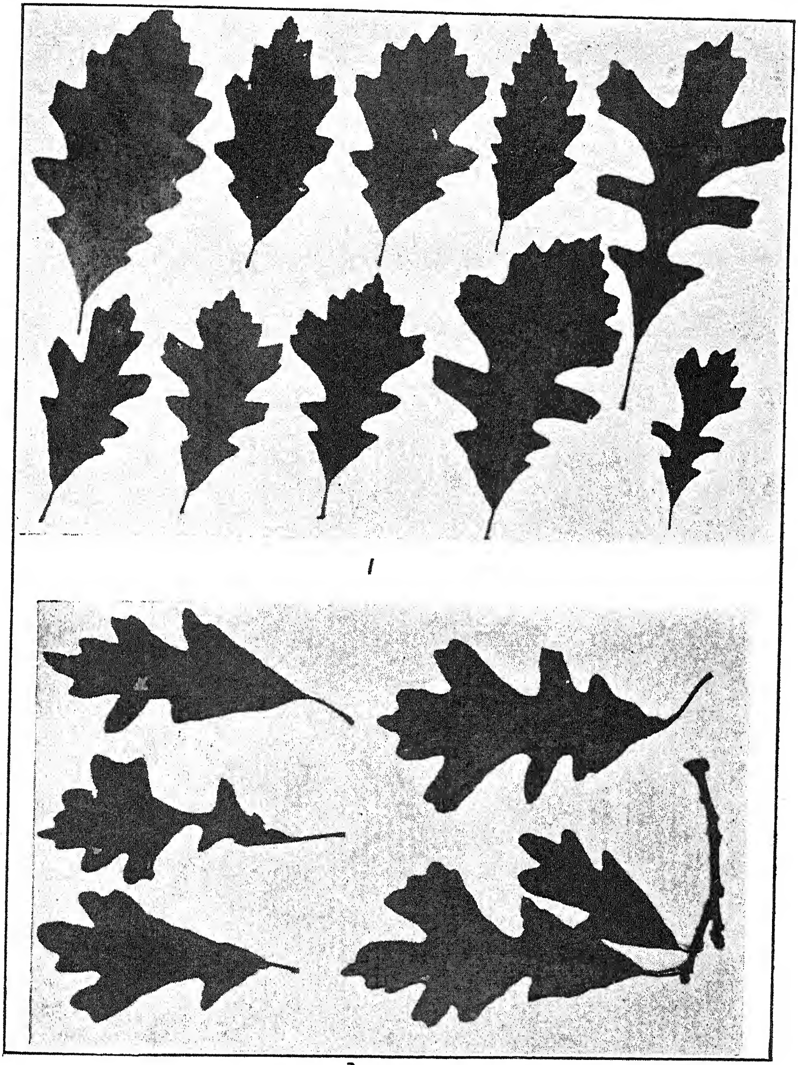
FIG. 1. *Quercus lyrata* Walt., a leafless tree.
FIG. 2. Cups and acorns, x .55.
FIG. 3. Young leaves and flowering twig, x .42.

PLATE 17

FIG. 1. Mature leaves of *Quercus lyrata*, x .24.
FIG. 2. Old leaves, taken a year earlier, x .30.



QUERCUS LYRATA Walter



2

QUERCUS LYRATA WALTER

References to the algae in the Chinese classics

W. M. Porterfield, Jr.

(WITH ONE TEXT FIGURE)

The following notes on the algae referred to in ancient Chinese literature are at best sketchy, but are offered nevertheless for what they are worth. The references to the texts and the translations thereof are quoted on the authority of Mr. Y. T. Chu, Instructor of Biology at St. John's University, Shanghai, China, and Mr. C. F. Wu, formerly of St. John's, now of Cornell. The writer presents this paper with a view to throwing some new light on the development of science in general, and to introducing to the West, besides, some evidences of Far Eastern activity in this line, which parallels, if not predates, that of Europe.

Agriculture in China dates back to Shen Nung,* an emperor of the legendary period, 3000 B. C. He was said to be the first farmer and taught the people to till their fields. Since this mythical age, the people of China have been farmers primarily. As the Old Testament was essentially the expression of an agricultural and pastoral people and is, in consequence, replete with similes and references to plants and animals, so in the Chinese classics we find the farming life of the people, a life of continuous touch with nature, coming to expression in the frequently recurring allusions to animals and plants, and in the use of terms connected therewith. Long before the Aristotelian age of hearsay and philosophical conjecture, the ordinary facts of farming and floriculture had entered the realms of Chinese literature in the form of terms serving as figurative expressions for desirable characters and virtues. In order to have given time for everyone to become so familiar with these original terms that they crept unconsciously into speech and literature as specific classifiers, observation of the form and structure of plants must already have proceeded far. This is offered as one evidence of age-old familiarity with the facts of nature. The second is coincident with the first and deals with the ideographs representing these terms and ideas. The discovery and use of the facts of nature called into being special ideographs to

*Appendix, "Peking," by Juliet Bredon.

represent them, so that owing to the character of the language and its slow evolution, we feel that the appearance of these specific terms in the ancient literature places the knowledge back of them at a very early date.

We shall confine ourselves to the algae in this paper. The Chinese character, as we are accustomed to term the ideograph, is built up of many radicals or elementary symbols supposed formerly to have been pictures which taken together represent an idea. The character for algae is Tsao (FIG. 1) and may be resolved into four radicals, the ones for grass, water, wood, and mouth, the latter being repeated three times. The mouth radical is a simple rectangle, which when repeated three times and placed in the form of a pyramid, two at the bottom and one on top, make up an ideograph which means rank or character. This latter smaller ideograph seems to carry with its meaning the idea of segmented, or possibly cellular (!) structure because of the shape of the thrice repeated box-shaped radicals. Evidently the idea in their minds from the character used was that of a grass-like, fibrous or stringy, cellular plant that grows in the water. Such an analysis leads us to believe that they had in general a good idea of what an alga is.

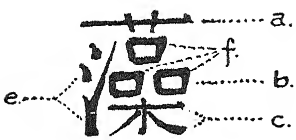


FIG. 1. TSAO

a, grass radical; *b*, mouth radical; *c*, wood radical; *e*, water radical; *f*, small ideograph meaning rank or segment.

The character for Tsao first appeared in one of the five classics, the Canon of Boems (FIG. 1). In the chapter Chao Nan there appears the following passage, the romanized version of which is here given: "'yü bih bien tsao" (with respect to the collecting of algae). This term is still used today. The term for water plants is a much simpler character and therefore is much more general in its meaning. It has the grass and water radicals but no specifically descriptive ones. There can be no confusion then in the use of these terms.

In support of the cellular or segmented idea of algae brought out in the analysis of the character, K'ung An-kuo, in the Canon of History, says that "an alga is an aquatic plant that has systematically arranged branching parts, and is used, therefore, (figuratively) to denote literature." He may here be referring

to the diagrammatic structure of *Hydrodictyon*. Nearly two thousand years ago in a pond beside the temple of Han Voo Tee, algae were said to have grown to a length of nine feet. Among other characteristics they were reported as having the appearance of a net from which certain water birds were said to have had great difficulty in extricating themselves. The people called this the water-net alga. The structure of such types was plainly visible under careful scrutiny, hence a netted or reticulate structure was specifically attributed to algae.

About 600 B. C., in a book entitled Sze tsen, occurs the following reference to algae: "Some algae are a delicacy fit for the most honorable guest, even for the king himself." At the present time country people gather *Nostoc* for food. This is called "Heaven vegetable." Red algae are dried and eaten by farmers who live near the sea. It is to some of these doubtless that the quotation refers.

The real knowledge in Chinese medicine as it exists today is based on the Chinese "Materia Medica," the edition of which was begun four thousand years ago. The present edition was written two hundred years ago in the Ming dynasty. Among other plants, Kw'un Boo, or *Laminaria* is mentioned as being useful for medicinal purposes, for which it is calcined after being washed and sun-dried. It is a common practice in China to pack open cuts with ashes in order to stop the bleeding. Whether there is any discrimination shown as to what kinds of ashes are used the writer is not prepared to say. If there is, it is interesting to note that in case preference was shown for ashes of kelps, they must have realized that some medicinal virtue was contained in them. Iodine as an element was probably not known to the Chinese but they may have realized its presence as a virtuous remedy in other things.

As in western countries the sea weeds of the China coast are used by the farmers nearby for fertilizer and also, when dried for fuel. Agar-agar is made by the Chinese out of certain species of sea-weeds, a well known fact to most scientists and technicians.

The morphological characters of these marine forms seem to have been as well known as the freshwater forms, if not better. Many were said to be attached to stones. The large leafed forms were known as ox or horse algae. Some float on the top of the water, others live at the bottom. Of the smaller forms,

many have long silk-like filaments, the longer ones more than thirty "segments" each, and others have the appearance of "uncombed hair."

Metaphorically the term for algae is used in a very complimentary sense. The elegance and beauty of essays was often designated by or compared to that of the algae. The term was used in praise of the thinking of a learned man, signifying that his thoughts were as systematically ordered as the parts of an alga. Judgment was in like manner complimented. The algae contributed not only to the language and literature of the Chinese but also to their art and superstitions. In an old book called Zong Shu, we find reference to conventionalized designs derived from algae being included in the embroidery of their garments. When the figures of algae appeared on the ends of the roof beams of their houses in brilliant colors, we find that the underlying idea was protection from fire. Because algae were known to be water plants, any evidence of them on houses was a protection against fire in that the former invoked the aid of their native element to drive away the fire spirit.

From this discussion we begin to realize that from direct references in ancient Chinese literature and an analysis of the ideograph, there is a possibility, if not a probability, that the knowledge of the algae as a distinct morphologic unit in the plant kingdom dates back to very early times, as compared with the state of knowledge in western countries. Moreover this knowledge seemed to be more wide spread amongst the people from the use of Tsao in a metaphorical sense, in its practical use as medicine, as food and fuel, and as fertilizer; as the basis of commercial products; and in the realization of its decorative value and its superstitious meaning.

A Lachnea with a botryose conidial stage

B. O. Dodge

(WITH SEVEN TEXT FIGURES)

While engaged in culturing species of Discomycetes for the purpose of studying the nature of the origin of the ascocarp, an interesting *Lachnea* was collected several different times in 1912 on a variety of substrata in the vicinity of New York City. The apothecium of this fungus, which was identified* at the time as *Lachnea abundans* Karst., originates in a long winding multicellular ascogonium, so similar to that described by Fraser† for *L. cretea* that, when we consider also the characters of the fruit bodies and mycelium, there appears to be little doubt that the fungi with which both of us were working are at least very closely related species. Believing that the characteristics of the primordia are of fundamental importance in determining relationships, further discussion, other than the mention made in a paper published at that time,‡ seemed unnecessary.

Miss Fraser does not state that she grew *L. cretea* in pure cultures. Her cultures were originally derived presumably by transfers from a plate culture overrun with moulds and some hyphomycetous fungus. It would be necessary to know whether *L. cretea* has a conidial stage like that which we have connected with *L. abundans* before we can be certain that the species are identical. In view of the discussions that have arisen since the publication by Seaver and Horne* of a paper on *Sclerotinia Geranii* and another paper by Godfrey† on *Sclerotinia Ricini*, both of these forms having *Botrytis* conidial stages, it has been thought advisable to point out that there are other types of Discomycetes which also have asexual fructifications closely resembling *Botrytis*.

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* The identification has been confirmed by Dr. F. J. Seaver, who is considering *L. cretea* as a possible synonym.

† Ann. Bot. **27**: 553–563. 1913.

‡ Bull. Torrey Club **41**: 165 1914.

* Mem. Torrey Club **17**: 202–206. 1917.

† Phytopathology **9**: 565–567. 1919.

The conidia of *Lachnea abundans* are smooth at maturity while those of *Sclerotinia Geranii* are rough or warted, otherwise their conidial stages are very similar. The connection between the apothecial and the conidial stage of *L. abundans* has been established repeatedly by cultures from single conidia and from single ascospores, apothecia arising in each case within a week or two after showing the spores.

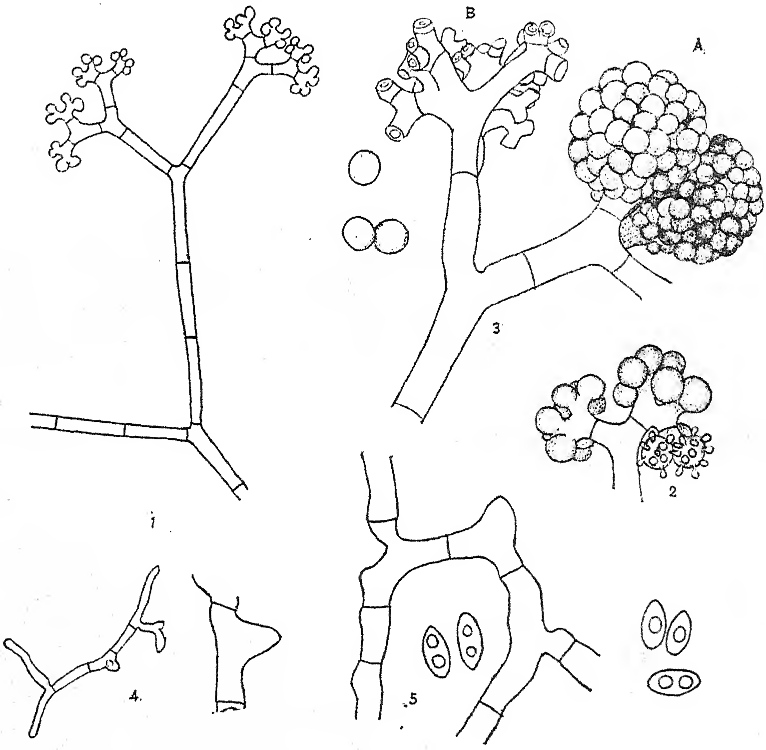

FIG. 1. Part of a dichotomously branched conidiophore showing the enlarged ends of the ultimate branchlets upon which spores will be borne.

FIG. 2. End branches of a similar stage more highly magnified, spore buds arising from two of the globular heads.

FIG. 3. Portion of an old conidiophore showing botryose clusters of spores, A, developed on about sixteen fertile ends; B, shows the collapsed ends of the conidiophore after the spores have been dislodged.

FIGS. 4 and 5. Germinated ascospore becomes a cell in the hypha; FIG. 5 also shows ungerminated ascospores.

Ascospores germinate very readily when the inoculated culture

medium is heated to 70° C. for about fifteen minutes. This method has been found effectual in inducing germination of ascospores of certain other species of Discomycetes.‡ The outlines of the spore are generally obscured as it germinates and becomes a cell in the hypha (FIGS. 4, 5,). The conidia as well as the ascospores remain viable for a long time if kept dry in the laboratory, the former, sometimes living three or four years. Should several conidia be sowed together in a culture there follows at once a great amount of anastomosing of the germ tubes.

The fungus grows well on almost any of the ordinary culture media. Conidiophores arise the second day in cultures on milk, bouillon, potato agar, etc. An agar medium in which the nutrient is a decoction from heated soil is especially favorable for the development of ascocarps. A potato dextrose agar gives an abnormal amount of conidial development. The conidia are formed on the spherical or knob-shaped ends of regularly dichotomously branched conidiophores, seven or eight such divisions often occurring. One might consider an aerial hypha whose main axis ends in a pair of sporophores as a part of the conidiophore system even though branches ultimately bearing conidia arise at irregular intervals from it. FIG. 1 shows a branch of the third order at the time spore formation is just beginning. A portion of such a branch is further enlarged in FIG. 2, showing conidial buds from two of the ultimate branchlets. As spores mature they hang together in botryose clusters covering about eight pairs of end branches (FIG. 3, A). At B in this figure the conidia have been dislodged, exposing the extremities of the conidiophore subdivisions, now collapsed. The length of the conidiophore system and the number of times dichotomous branching occurs depend of course upon the kind of nutrient in the medium. On soil decoction agar the sporophores are very short, and there is very little of the aerial type of hyphae. The mycelial hyphae on the other hand branch more or less dichotomously and in this respect also the fungus is like the *L. cretea* studied by Fraser. The color of the aerial hyphae, conidiophores and conidia in mass varies from pale ochraceous buff to vinaceous buff (Ridgway), depending on age and vigor of growth.

‡ Mycologia **4**: 218–222. 1912.

The conidia are spherical, smooth, faintly colored, pale ochraceous buff in mass, 7–9 μ in diameter. The ascogonia begin to appear, as noted, in about ten days, and mature fruit bodies will be formed within two or three weeks. Fraser lays considerable stress on the branching of the trichogyne end of the ascogonium of *L. cretea*, thinking such vegetative growth the "progressive degeneration" of Atkinson, indicates that the species is becoming apogamous. Many such abnormal or aborted ascogonia are always found in cultures of these Discomycetes and they should be carefully distinguished from those

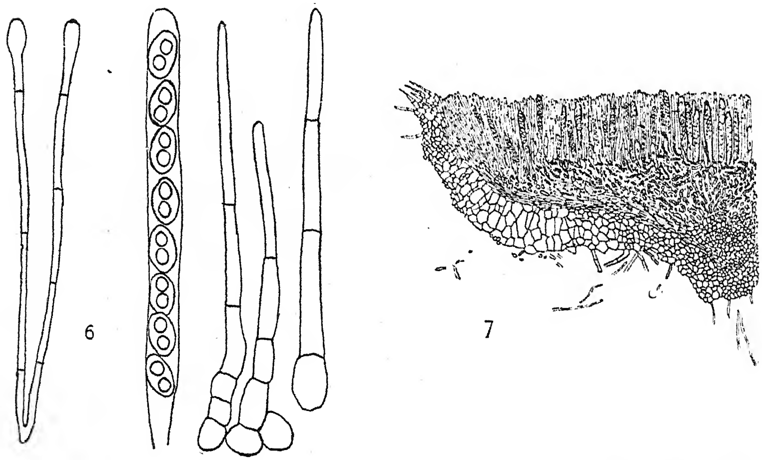

FIG. 6. Hairs from the margin of the apothecium, ascus with spores and paraphyses.

FIG. 7. Part of a section of a small apothecium showing the character of the cells of the wall and of the margin.

normal primoridia which develop into fruit bodies. Ascocarps of *L. abundans* (FIG. 7) are 1–3 mm. in diameter and uniformly ochraceous in color. The hairs (FIG. 6) are about 150 μ long, the asci 130–150 μ, and the ascospores 7–8 x 12–14 μ. The paraphyses, which are enlarged rather abruptly at the ends, are 4–5 μ broad.

It is certainly dangerous to place too much weight on the asexual spore forms in determining relationships of their ascogenous stages in the face of these apparently anomalous cases and such others as we find in *Ascobolus magnificus*, which is connected

with a *Papulospora** similar to those forms hitherto thought to belong to *Melanospora*. If one, following Saccardo, for example, seeks to find a description which might apply to the conidial stage of *Sclerotinia Geranii* or of *Lachnea abundans* he turns directly to the forms along with *Botrytis cinerea* on the basis of the spore clusters. It seems to the writer, therefore, an impossible task to determine the real generic affinities of species of form genera from a study of the conidial or pycnidial stages alone. Brierly* has recently published a paper on *Botrytis cinerea*. His argument is based entirely on the assumption that this species has no perfect or ascogenous stage. It is certainly unusual to state that a fungus has no ascocarpic stage simply on the basis of large numbers of cultures that produce only conidial fructifications. The recent work of Bensaude, Kniep and others, on several of the well known Basidiomycetes emphasizes the importance of growing in pairs strains or races derived from different spores, at least as a last resort, in attempts to obtain the "perfect" stages. We are finding more and more forms in which a strain, which is sterile when grown alone, still, when grown together with some other strain, at once takes part in the development of a "perfect" stage.

There is no question that *Lachnea abundans* is homothallic, a culture from a single conidium or a single ascospore being capable under suitable conditions of giving rise to ascocarps. Whatever may be the standing of the species now commonly referred to the form genus *Botrytis*, after study has revealed their ascomycetous connections, it is interesting to find an "imperfect" fungus with a botryose conidial stage connected with a little *Lachnea* which may be so easily cultured on ordinary media.

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* Mycologia **12**: 115–134. 1920.
* Phil. Trans. Roy. Soc. B. **210**: 83–114. 1920.

INDEX TO AMERICAN BOTANICAL LITERATURE
1916–1922

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Reviews, and papers that relate exclusively to foresty, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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BULLETIN

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NOVEMBER, 1922

Effect of external and internal factors on the germination of fungous spores*

WM. L. DORAN

(WITH TWO TEXT FIGURES)

The greater part of the work which has been done on the germination of fungous spores has been incidental to studies of the life histories of fungi. References to spore germination are in most cases isolated and few attempts have been made to draw any general conclusions from the results obtained. Since all fungous diseases must begin with infection and since the germination of the spore is the forerunner of infection, further knowledge of the conditions which favor or inhibit spore germination is of great practical importance. In this paper are described the results of the writer's study of the effect of various factors on the germination of fungous spores.

It is becoming increasingly common for field studies of the efficiency of fungicides to be preceded by laboratory tests of the toxicity of fungicides to fungi. If fungous spores are to be germinated both in the presence and absence of fungicides, it is important that all other conditions be identical and at or near the optimum. It is therefore necessary that optimum conditions for the germination of the spores be known before the laboratory tests of fungicides are made.

Frequent references are made in the literature to the effect of prevailing climatic conditions on the outbreak or severity of

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epiphytotics of fungous origin. Field experiments and observations on the effect of weather on diseases of plants are affected by a very complex set of factors. Conclusions cannot safely be drawn until the various factors have been separately studied and such study is more easily effected in the laboratory than in the field.

Factors influencing the germination of fungous spores may be divided into two groups, internal and external. The internal factors are maturity of the spore, longevity of the spore, animation, and a poorly understood factor which may be called vitality of the spore. The external factors are oxygen, presence of moisture either in the form of water vapor or water of condensation (rain or dew), temperature, light, nutrient substances, toxic substances, and duration of the time period during which one or more than one of the factors acting jointly exert their influence on the spore of the fungus.

EXPERIMENTAL METHODS

The germination of the following fungous spores was studied: conidia of *Venturia inaequalis* (Cke.) Wint., conidia of *Sclerotinia fructigena* (Pers.) Schrt., spores of *Alternaria Solani* (E. & M.) Jones & Grout., spores of *Botrytis cinerea* Pers., spores of *Rhizopus nigricans* Ehr., aeciospores and urediniospores of *Cronartium ribicola* F. de Wal., aeciosopres of *Gymnosporangium clavipes* C. & P., and teliospores of *Puccinia Malvacearum* Mont. The spores of the fungi were obtained fresh from the living host in all cases except *Alternaria Solani*. Spores of parasitic fungi to be used for germination tests were found to be more dependable when obtained from this source than when obtained from fungi growing on artificial media. A spore obtained from the living host is presumably possessed of its full natural vigor. A spore obtained from a fungus growing on artificial media may have been subjected to a debilitating influence, or may, on the other hand, have become unnaturally resistant to adverse conditions. In this connection it should be noted that Young and Cooper (1) found that when *Glomerella rufomaculans* was grown on agar eight to fifteen days, the spores were more resistant to the toxic action of fungicides than when the fungus had been grown on agar only four to eight days. If fresh spores from the living host are not obtainable and spores from artificial culture must be used, it is the experience of the writer that all spores

the germination of which is to be studied should be of the same age. The germination of spores from a second culture transferred from the first should not be compared with the germination of spores from the first culture.

Distilled water was the medium in which the spores were placed to germinate. As is subsequently described more in detail, it was soon evident that the distilled water contained an insufficient amount of air for spore germination. Consequently, the distilled water was in all cases aerated before being used. The aeration was accomplished by drawing air through the water for about thirty minutes by means of an aspirator and an Allihn gas washing bottle.

On culture plate benches in moist chambers were placed glass slides and on them drops of water either containing spores in suspension or the spores were shaken off into the drops. It is important that all drops of water be approximately equal in size especially when the toxic action of fungicides is to be tested. Clark (2) studied spore fermination in hanging cultures. Duggar (3) used that method also and a modification of it, placing the cells in small Petri dishes. Mains (4) germinated fungous spores in hanging drops on the cover of a Petri dish.

When the cardinal temperatures for the germination of the spores being studied was unknown, the first step consisted in the determination of the optimum temperature for germination, and in all later tests the spores were germinated at their optimum temperature. Constant temperatures were secured by the use of a DeKhotinsky electric oven and a Hearson incubator.

The next point determined was the minimum length of time in which all the viable spores of each fungus will germinate at the optimum temperature. At least six hours more than this minimum time period was allowed to elapse before removing the slides from the moist chambers and determining the relative number of spores germinated. If slightly less than sufficient time is allowed a narrower range of optimum temperatures will be found than if more time is allowed, resulting, when the results are plotted, in a temperature-germination curve more acute than flat at its summit. If too long a time passes before the germinating spores are counted, the germ tubes will have grown and branched so as to make counting difficult and uncertain. *All* data are based on relative number of spores germinating.

The spores were counted by the use of a micrometer disc ruled in squares and the help of a tallying register. The micrometer disc ruled in squares is placed in the ocular, the slide bearing the drops of water containing spores is placed on the stage of the microscope and moved by means of a mechanical stage until the outer line on the micrometer disc appears as a tangent to the circumference of the drop. The germinating spores appearing between the first two lines of the micrometer disc are counted, and then the ungerminated spores in this area are counted. When one field as limited by the lines on the micrometer disc is counted, the slide is moved enough to bring a new field into view for counting. This is continued until a total of fifteen hundred to two thousand spores, both germinated and ungerminated, have been counted. This necessitates the examination of several or many drops. From the count obtained, the relative number of spores germinating is figured, germination elsewhere being raised proportionately. This accuracy of counting is most necessary when the relation between temperature and spore germination is being determined. It is not as necessary in the case of toxicity tests with fungicides except when the differences in toxicity are small.

RELATION OF THE VIABILITY OF THE SPORE TO ITS AGE

Maturity.—Until the spore has attained a certain age or degree of maturity, it cannot germinate. Even before a spore is really mature, it can germinate if other conditions are near enough to the optimum. For example, the range between the minimum and maximum temperature is considerably greater for the germination of a mature urediniospore of *Puccinia Antirrhini* than for the germination of an immature urediniospore of this fungus, collected the first day it breaks through the host surface. The immature spore may be prevented from germinating by the action of fungicides not of sufficient concentration to prevent the germination of the mature spore. A solution containing 0.257 per cent copper sulphate prevents the germination of mature spores of *Uromyces caryophyllinus*. A solution containing only half as much copper sulphate prevents the germination of immature spores of this fungus. It should be understood that mature and immature spores may not differ morphologically. Spores here referred to as immature are so called because when collected young they did not germinate,

although older spores from the same fungus did germinate. All conclusions as to germination should be based upon the behavior of mature spores.

It is possible by exercising care in obtaining spores to separate the mature from the immature to some extent at least. When a fungus has matured its spores, they are usually freed in such a way that they may be disseminated by the movement of air or water. So far as possible, the natural method should be duplicated in obtaining spores for experimental purposes. When a scab lesion on the fruit or leaf of the apple is washed, it is probable that only mature conidia and perhaps a few dead conidia of *Venturia inaequalis* are detached. But when a similar lesion on the fruit or leaf of the apple is brushed or scraped, it is probable that many immature conidia are also detached. In the case of all except the fungi having very short-lived spores the immature spores on a fresh lesion greatly outnumbered the dead spores. When the writer obtained conidia of *Venturia inaequalis* by brushing apple scab lesions the relative number of conidia which were capable of germinating was only twenty-five as compared with the relative number of one hundred germinating when the conidia were obtained by washing lesions with a stream of water from a pipette. When fungous spores are to be obtained for germination studies they should be freed from the host as gently as possible and in as nearly as possible the same way in which they would be removed in nature. In this connection it is interesting to note that Jones (5) found that the ascospores of *Pseudopeziza Trifolii* and *P. Medicaginis* germinate readily when they are discharged naturally but not when they are crushed out of the ascus.

Some attention has been given to the later maturing of spores which were detached from the fungus while still immature. Schaffnit (6) is of the opinion that unless fungous spores are internally mature before they are detached from the fungus, they never gain power to germinate. But the results of Melhus and Durrell (7) indicate that some urediniospores can mature after being detached from the fungus.

With the exception of the spores of *Botrytis cinerea*, all the fungous spores studied by the writer were apparently killed if detached when immature.

It is possible in some cases to distingiush between mature and immature spores by their relative position in the fruiting parts

of the fungus. The only spores of *Sphaerotheca mors-uvae* which Foreman (8) induced to germinate were the large spores found at the tips of the chains of spores. Weimer (9) observed that the teliospores of *Gymnosporangium Juniperi-virginianae* which are situated at the apex of the spore horn germinate best and he attributed this to their maturing earlier.

As the season advanced in the autumn the writer found it increasingly difficult to secure good germination of the conidia of *Venturia inaequalis* even when conidia were obtained from fresh lesions. This is not attributed to the presence of a greater number of spores too old to germinate, for they would probably have been washed away earlier. It is believed that a larger number of immature conidia of this fungus were present in the autumn. It is not unlikely that the process of maturing of the spore is slower when the temperature is lower.

Very little work has been done on the relation of the viability of fungous spores to the conditions under which the host plant grew and in which the fungus developed. If certain conditions may retard the maturing of the spores, it is quite possible that other conditions during their development may entirely prevent their ever germinating. On the other hand, certain conditions during development of the spore may result in an extremely vigorous spore. Spores may be mistakenly designated as mature and immature, on the basis of their behavior when placed under optimum conditions for germination, when they should properly be designated as spores of the same age, some vigorous and others without vigor.

The inability to germinate any fungous spore under all possible combinations of conditions may be temporarily explained by the supposition that the spores are either dead, non-functioning or in a resting condition. There are perhaps many resting spores not now recognized as such. Reed and Crabill (10) have advanced the theory that a rest period is necessary for the aeciospores of *Gymnosporangium Juniperi-virginianae* and that these spores do not germinate until the spring following their dispersal.

Longevity.—For all spores there is a maximum time limit, variable with the environmental conditions, beyond which the spore cannot germinate. The spore may be alive and too old to germinate or it may be dead. A live spore too old to germinate under the range of conditions within which it formerly could germinate is, according to the observation of the writer, able

to germinate when all conditions approach the optimum. There comes a time when even this is not stimulative and the spore is then dead so far as we can tell. Neglect of the age factor may render any study of spore germination undependable.

In studying the relation of the age of spores to their viability, points to be considered are the date of collection, the conditions in which the spores are placed after collecting, and the length of time spores remain viable after their collection. Aeciospores of *Cronartium ribicola* were found to germinate with diminishing vigor as the season advanced. The aeciospores of this fungus were collected on May 25th, June 4th and June 12th from the same sorus. On the first date, the relative number of spores germinating was one hundred, on the second date forty-nine and on the third date twenty-nine. Observations with this and other fungi indicate that although there is at first a sharp falling-off in viability, it is retained for a comparatively long time and only gradually lost. In any spore germination studies which involve comparisons, spores should be used which are known to be of the same age.

Among the factors bearing upon the retention of viability after the collection of spores are moisture, temperature, and freedom from or connection with the parent. Detachment from the parent was not found to have any effect on the length of life of the aeciospores of *Cronartium ribicola*, viability decreasing the same in both cases. When collected, the relative number of these spores germinating was one hundred, after having been collected thirty days the germination fell to seventy-three, after fifty days to five, and after fifty-five days no spores germinated.

Freshly collected aeciospores of *Cronartium ribicola* were stored indoors at temperatures of 7° C., 15° C., and 23° C. These various temperatures had no effect upon the longevity of the spores. But aeciospores stored in moist air retained their viability longer than those stored in dryer air. At least in the case of this fungus moisture is of more importance than temperature in its effect on the length of life of the spore. This effect of moisture is to be expected; for all spores lose water in dry and moist air, and if other conditions are equal they should live longer in moist air than in dry air. These results agree with those of Anderson (**11**) who found that in a humid atmosphere

the spores of *Cylindrocladium scoparium* live for several weeks but that in a dry atmosphere they die in fifteen days.

Under no conditions did aeciospores of *Cronartium ribicola* germinate when more than eight weeks old. A few cases are recorded in the literature of aeciospores of this fungus living longer, but it is probable that in such cases germination is reduced to a trace and that even that small germination occurs only when all environmental conditions are very close to the optimum for a time.

The conidia of *Venturia inaequalis* produced on the leaves are somewhat shorter lived than those produced on the fruit. According to Aderhold (**12**) the conidia of this fungus retain their viability not more than eight weeks. The writer found none of the conidia of this fungus to live more than six weeks on the fruit and not more than four weeks on the leaf. With the aging of the leaves in the fall, the life of the conidia becomes even shorter. Difficulty was experienced in germinating conidia from fruit in storage. The scab lesions, however, were contaminated with *Cephalothecium roseum*, the presence of the conidia of which in the drops of water may have been partly responsible for the failure of the conidia of *Venturia inaequalis* to germinate. As will be described later, the presence in a drop of water of the spores of several fungi prevents or retards the germination of all the spores as compared with germination in a drop of water containing only the spores of one fungus.

One of the factors bearing upon the retention of viability by spores after their collection is their freedom from or connection with the fungus or each other. Anderson and Rankin (**13**) found that ascospores of *Entothia parasitica* which remained in the perithecia in the bark germinated after being stored dry for one year. But when ascospores were removed and separated for only five months they lost the power to germinate. According to Burrill (**14**) the spores of *Glomerella rufomaculans* remain viable for a long time when their soluble protective coating in which they are imbedded is present. But if it is washed away, the spores soon lose the power of germination. Anderson and Rankin (**13**) found that if the pycnospores of *Entothia parasitica* are stored in a dry place they live at least one year. But if the pycnospore horns are placed in water and the water allowed to evaporate so as to leave the spores separated, they do not retain their viability more than one month.

It is possible that in most cases the mucilaginous covering in which many spores are imbedded serves to prolong the life of the spore. For this reason, when studying the germination of such spores, it is advisable that only those still adhering together in their protective coatings be used.

Exposure to light shortens the life of some spores, as shown by the results of Hoerner (15) with the urediniospores of *Puccinia coronata*.

Some attention has been given to the longevity of the spores of the Uredinales. The sporidia are the shortest-lived spores of this group of fungi. According to Reed and Craybill (10) the sporidia of *Gymnosporangium Juniperi-virginianae* do not live more than six days in dry air. Spaulding (16) reports that the sporidia of *Cronartium ribicola* live less than ten minutes at room temperature with the humidity at ninety. Duff (17) found that two weeks after the collection of the urediniospores of *Cronartium ribicola* their germination was so reduced as to become practically negligible. The life of a teliospore measured from the time of its formation to its death may be long, but the life of a teliospore if measured from the close of its normal resting period until its death is not long; it is apparently as short in some cases as the life of many non-resting spores. Melhus, Durrell, and Kirby (18) report that the teliospores of *Puccinia graminis*, which mature in April, cannot germinate after the end of June following.

The experience of the writer is to the effect that in most cases aeciospores are longer lived than urediniospores. The average life of urediniospores is between thirty and sixty days. The average life of the aeciospore is about 50 per cent greater. The several spore forms of the Uredinales behave alike in this, that as they grow older their range between maximum and minimum conditions for germination becomes narrower.

EXTERNAL FACTORS

Temperature relation.—One of the most important external factors bearing upon the germination of fungous spores is the temperature relation. In order to draw from the scattered data in the literature some more general conclusions than we now have as to the cardinal temperatures for the germination of fungous spores, TABLE I has been prepared. In it are given the cardinal

temperatures and the range of temperature for germination of thirty fungous spores.

If the optimum temperature for the germination of the spores of *Plasmodiophora Brassicae*, which Chupp (19) found to be 27°–30° C., is typical for the Myxomycetes, then the temperature requirements for the germination of the spores of the slime moulds must be higher than those of fungi.

A study of TABLE I shows for the germination of the spores of several groups of fungi the following average cardinal temperatures and average range between minimum and maximum temperatures. For the germination of the Phycomycetes the average cardinal temperatures are 1.2° C., 18° C., and 26.1° C., and the range is 25.0 degrees Centigrade. For the germination of the aeciospores of the Uredinales, the average cardinal temperatures are 6.5° C., 13.0° C. and 22.0° C. and the average range is 15.5 degrees Centigrade. The average cardinal temperatures for the germination of the urediniospores are 5° C., 16.2° C., and 28.9° C., and the range through which these spores can germinate is 23.9 degrees Centigrade. In the case of teliospores the cardinal temperatures for germination are 7.4° C, 19.9° C., and 28.1° C., and the range for germination is 20.7 degrees Centigrade.

Temperature limits are narrower for the production of sporidia by germinating teliospores than for the production of germ tubes only. This is illustrated by the results obtained by the writer with the teliospores of *Puccinia Malvacearum*. At temperatures as low as 5° C. promycelia are produced but no sporidia. Above 23° C. promycelia are produced but sporidia are rare.

These results agree with those of Dietel (29) who found that above 23° C. the teliospores of *Puccinia graminis* produce no sporidia but only germ tubes. Reed and Craybill (10) noticed that the teliospores of *Gymnosporangium Juniperi-virginianae* do not germinate when the temperature rises to 24° C. But above that temperature they sometimes develop promycelia.

When the Fungi Imperfecti and the one representative of the imperfect stage of the Ascomycetes named in TABLE I are considered collectively, it is seen that for the germination of these spores the cardinal temperatures are 7.3° C., 23.1° C., and 39.6° C. Between the minimum and maximum temperature limits for germination there is an average range of 32.3 degrees Centigrade.

TABLE I

Cardinal temperatures and range of temperature for the germination of the spores of representative fungi.

Authority*	Fungus	Cardinal Temperatures Min.	Opt.	Max.	Range
18	*Plasmodiophora Brassicae*	—	27°–30° C.	—	—
20	*Plasmopora viticola*, conidia	—	25°–30° C.	—	—
21	*P. viticola*, conidia	—	25°–35° C.	—	—
22	*Cystopus candidus*, conidia	0° C.	10° C.	25° C.	25
23	*Phytophthora infestans*, conidia	2°–3° C.	12°–13° C.	24°–25° C.	23
24	*Peronospora parasitica*, conidia	—	8°–12° C.	29° C.	—
25	*Gymnosporangium clavipes*, aeciospores	8° C.	14° C.	25° C.	17
25	*Cronartium ribicola*, aeciospores	5° C.	12° C.	19° C.	14
4	*Puccinia Phlei-pratensis*, urediniospores	—	18° C.	30° C.	—
4	*P. coronata*, urediniospores	—	18° C.	30° C.	—
26	*P. coronata*, urediniospores	7° C.	—	30° C.	23
7	*P. coronata*, urediniospores	1° C.	17°–22° C.	35° C.	34
26	*P. rubigo-vera*, urediniospores	2° C.	—	31° C.	29
26	*P. graminis*, urediniospores	2° C.	—	31° C.	29
27	*P. dispersa*, urediniospores	10°–12° C.	18°–20° C.	25°–27° C.	17
25	*P. Antirrhini*, urediniospores	5° C.	10° C.	20° C.	15
28	*P. Sorghi*, urediniospores	4° C.	14° C.	25° C.	17
25	*Cronartium ribicola*, urediniospores	8° C.	14° C.	25° C.	17
25	*Uromyces caryophyllinus*, urediniospores	4° C.	14° C.	29° C.	25
4	*Uromyces Trifolii*, urediniospores	—	16° C.	34° C.	—
10	*Gymnosporangium Juniperi-virginianae*, teliospores	11° C.	15° C.	29° C.	18
9	*G. Juniperi-virginianae*, teliospores	7° C.	23°–24° C.	29° C.	22
29	*Puccinia graminis*, teliospores	9° C.	22° C.	23° C.	14
18	*P. graminis*, teliospores	5° C.	20° C.	25° C.	20
29	*P. Larici*, teliospores	6° C.	—	—	—
25	*P. Malvacearum*, teliospores	3° C.	14° C.	30° C.	27
18	*P. graminis*, basidiospores	—	15°–20° C.	—	—
30	*Colletotrichum lagenarium*	7° C.	22°–27° C.	—	—
31	*Melanconium* sp.	—	23°–27° C.	—	—
32	*Phyllosticta Antirrhini*	—	25° C.	—	—
33	*P. Antirrhini*	18° C.	—	47° C.	29
34	*Alternaria Solani*	1°–3° C.	26°–28° C.	37°–45° C.	44
35	*Septoria* sp.	—	24°–28° C.	34° C.	—

* Numbers refer to the literature cited.

For these several groups of fungi the minimum temperatures for spore germination occur between 1° and 7.4° C. The optimum temperatures are all between 13° and 23.1° C. The maximum temperatures for the germination of the spores occur between 22° and 39.6° C. The Phycomycetes have the lowest minimum temperatures, followed in order by the urediniospores, the aeciospores and the teliospores of the Uredinales. Teliospores and the spores of the Fungi Imperfecti have the highest, and about the same minimum temperature for germination.

Of these five groups of fungous spores, aeciospores have the lowest optimum temperature for germination followed in turn

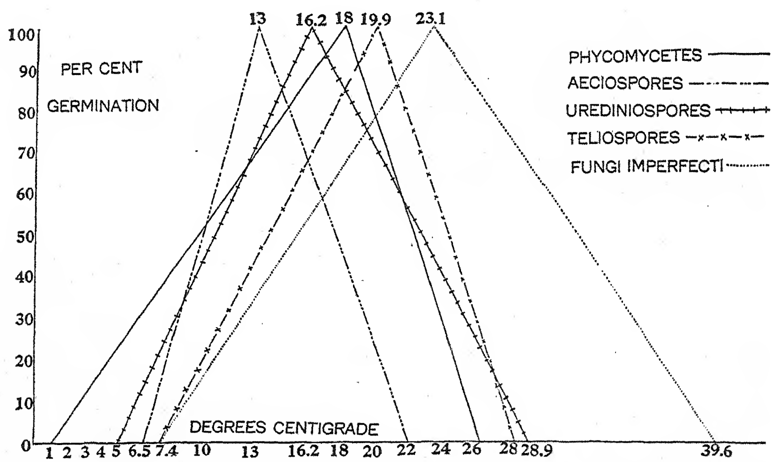

FIG. 1. Curves showing the cardinal temperatures for the germination of the spores of representative fungi.

by urediniospores, conidia of Phycomycetes, teliospores, and then by the spores of the Fungi Imperfecti, which seem to have the highest optimum temperature for germination.

Aeciospores have the lowest maximum temperature for germination, and the spores of the imperfect fungi have the highest. About midway between these two come urediniospores. Their maximum temperature for germination is higher than that of the conidia of the Phycomycetes.

The spores of the Fungi Imperfecti can, it would appear, germinate through the greatest range of temperature. As compared with this, the range of the Phycomycetes is 77 per cent

as great, that of the urediniospores is 74 per cent as great, that of the teliospores is 64 per cent as great, and the range of the aeciospores is only 48 per cent.

FIG. 1 shows the ranges and the cardinal temperatures for these groups, and their relative positions.

The results obtained by the writer and others indicate that any departure from optimal conditions tends to narrow the temperature limits within which fungous spores will germinate. The literature contains a very few references to the relation which

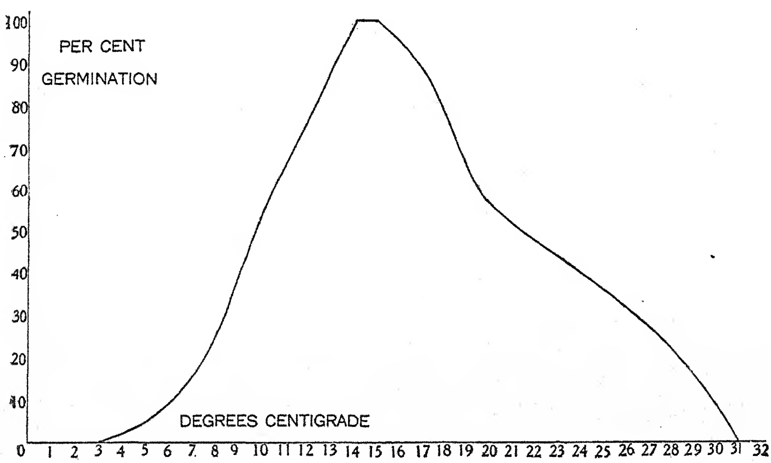

FIG. 2. Curve showing temperature limits for the germination of the conidia of *Venturia inaequalis.*

exists between the temperatures required for the process of spore germination and the other environmental conditions prevailing during that period. Gardner (**30**) found that the minimum temperature for the germination of the spores of *Colletotrichum lagenarium* is 7° C. when the spores are in exposed drops of water, but it is 14° C. when the spores are in hanging drops of water. When these spores are in exposed drops of prune decoction, the minimum temperature for their germination is 4° C. It would appear that the presence of nutrient substance and the availability of sufficient oxygen both tend to lower the minimum temperature.

The work of the writer included the determination of the cardinal temperatures for the germination of the conidia of *Venturia inaequalis*, the spores of *Botrytis cinerea*, and those of

Rhizopus nigricans. Cardinal temperatures for the germination of the other spores used had been previously determined (Doran, 25).

The results obtained with the conidia of *Venturia inaequalis* are shown in TABLE II and by the curve in FIG. 2. For the germination of the conidia of *Venturia inaequalis*, the minimum temperature is 3° C., the optimum temperature is 14°–15° C., and the maximum temperature is 31° C. The conidia can germinate through a range of twenty-eight degrees.

This is an unusually long range. Since the causal fungus of apple scab is not especially exacting as regards temperature for the germination of the conidia the indications are that the distribution or severity of this disease, following the primary infection by the ascospores is dependent more upon rainfall than upon temperature. The conidia of *Venturia inaequalis* are disseminated most freely during June, July and August. As shown in FIG. 2, warm nights do not prevent their germination.

A study of the temperature-germination curve in FIG. 2 shows that the falling off in germination of the conidia is more rapid from the optimum to the minimum temperature than from the optimum to the maximum temperature. Over 40 per cent of the number of spores germinating at the optimum (14°–15° C.) germinate at 9° C. and 24° C., respectively.

TABLE II

Effect of temperature on the germination of the conidia of *Venturia inaequalis*

Relative germination at different temperatures measured in degrees Centigrade

	2°	3°	5°	8°	10°	12°	14°	15°	18°	20°	24°	28°	30°	31°	32°
	0	1	2	20	52	76	100	100	90	61	42	26	14	1	0
	0	0	4	18	60	80	100	100	68	58	46	24	10	2	0
	0	1	1	23	55	69	100	100	70	55	38	20	12	0	0
	0	1	5	25	58	81	100	100	81	52	40	19	8	3	0
Mean	0	0.75	3	21.5	56.2	76.5	100	100	77.2	56.5	41.5	22.2	11	2	0

In these studies of the relation of spore germination to temperature, as to all other external conditions, the relative number of spores germinating was taken as an indicator of the reaction

of temperature. Johnson (26) and Melhus and Durrell (7) preferred to use the growth or length of the germ tubes as an indicator of the temperature reaction. To test the relative merits of these indicators, both were used by the writer in the case of germinating conidia of *Venturia inaequalis*. When the optimum temperature for germination was based upon length of germ tube rather than upon number of spores germinating the optimum was less sharply defined. The writer believes that to consider length of germ tube rather than number of spores germinating involves growth rather than germination and so should be studied separately, for there is no reason to believe that the optimum temperature for the growth of a fungus is the same as the optimum temperatures for spore germination. Melhus (22) found the optimum temperature for the germination of the conidia of *Phytophthora infestans* to be 12°–13° C. Jones, Giddings and Lutman (30) found that the optimum temperature for the growth of this fungus is between 16° and 19° C. The cardinal temperatures for the germination of the conidia of *Botrytis cinerea* were found to be minimum 7° C. to 17° C., and maximum 26° C. For the germination of the spores of *Rhizopus nigricans*, the minimum temperature was found to be 10° C. and the optimum 19° C. to 20° C. All later studies of the germination of *Botrytis cinerea* were made at 15° C. and of the germination of *Rhizopus nigricans* at 19° C.

Time relation.—The length of time required for the process of spore germination is in itself an important factor. If before the elapse of the necessary time period the environmental conditions depart from the optimum, the germination process is impeded or stopped and the spore may even be killed. In all laboratory studies of spore germination, if conditions in nature are to be duplicated, no more time need be allowed for germination than that in which nearly optimal conditions are likely to continue in nature. Probably most fungous spores begin and complete germination between darkness and daybreak. One of the principal natural protections of plants from pathogenic fungi is the failure of environmental conditions to remain between minimum and maximum limits long enough for spore germination. Infection does not occur if during the protrusion and growth of the germ tube the necessary precipitated moisture evaporates or the air falls below a certain degree of humidity or the temperature passes beyond minimum or maximum limits.

According to the observation of the writer, extremes of temperature at this time, if not too long continued, have no more serious effect than to temporarily stop the growth of the germ tube. This is resumed when the temperature again approaches the optimum. But when the humidity of the air falls, the results to the spore are more serious. In the case of all spores worked with, and especially with conidia of *Venturia inaequalis*, it was found that a germinating spore can live but a short time in a dry environment, which to an ungerminated spore would be in no way detrimental. A return to optimal conditions proved such spores to be not merely inhibited but dead.

Wallace (37) considered the length of time apple trees remain wet so as to allow spore germination an important factor in determining whether or not a certain rain would permit infection by *Venturia inaequalis*. He found that the ascospores of this fungus can germinate in four hours but he believed that apple trees must remain wet eight or ten hours to be abundantly infected. The writer will here comment that the further the temperature is from the optimum for germination, the longer must the surface of any plant remain wet in order for the spores on it to germinate and infect the host.

Duggar (3) found that after drying the germinating spores of *Botrytis* would grow no more. But the germinating spores of *Aspergillus* showed new growth after being dried several days. Duggar's results with the parasitic form mentioned are in agreement with the results secured by the writer, who worked only with parasitic forms.

The relation of environmental factors to the time required for spore germination has occasionally been noted. The amount of moisture present may affect the length of time in which the spore germinates. Taubenhaus (38) reports that the spores of *Glomerella rufomaculans* from the sweet pea germinate in from six to twenty-four hours, depending on whether there is much or little moisture present in the atmosphere.

The writer has noticed that spores germinating in moist air require a relatively longer time for the process than do the same spores germinating in or on precipitated moistqre.

Anderson (11) observed that at 25° C., which is within optimal limits for the germination of the spores of *Cylindrocladium scoparium*, the spores of this fungus begin to germinate in two to three hours, but at lower temperatures a longer time is neces-

sary for their germination, five hours at 12° C. and twenty-four hours at 8° C. Tisdale (**39**) found that at 4° C., which is their minimum temperature for germination, the spores of *Didymellina iridis* germinate in twenty-one hours, but at their optimum temperature of 20° C. to 26° C. these spores germinate in two and one half hours, and at their maximum temperature which is 30° C. their germination requires eleven hours.

The presence of a nutrient solution may hasten the germination of some spores. Gardner (**30**) found that the spores of *Colletotrichum lagenarium* germinate in five hours in agar but require ten to twenty-four hours for their germination in distilled water at the same temperature.

It appears that immature spores and aged spores may germinate more slowly than mature spores. Melhus, Durrell, and Kirby (**18**) found that both before and after the teliospores of *Puccinia graminis* have completed their rest period, the time required for their germination is longer than that required just as they end their rest period in the spring.

The results mentioned above indicate that all fungous spores germinate most rapidly when all environmental conditions are nearest to the optimum.

TABLE III shows the time necessary for the germination of twenty-three representative fungous spores. After a study of this table it is possible to draw certain conclusions as follows: The average time required for the germination of fungous spores is about twelve hours; for the germination (indirect) of the conidia of the Phycomycetes it is four hours; for the ascospores of the Ascomycetes it is thirteen hours; for the germination of the chlamydospores of the Ustilaginales it is twenty-one hours; for the germination of the aeciospores of the Uredinales it is ten hours; for the germinations of the urediniospores of the Uredinales it is five hours; for the germination of the teliospores of the Uredinales it is three hours; and the average time required for the germination of the spores of the Fungi Imperfecti is seventeen hours.

The writer has found that the length of time necessary for the germination of the fungous spores named in TABLE IV is: aeciospores of *Cronartium ribicola* twelve hours; urediniospores of *Cronartium ribicola* five and one-half hours; for the production of basidia by the teliospores of *Puccinia Malvacearum* two hours; one hour more, a total of three hours are necessary for the

production of sporidia by the teliospores of this fungus; aeciospores of *Gymnosporangium clavipes* require four hours; conidia of *Venturia inaequalis* about twenty-four hours; and conidia of *Sclerotinia fructigena* five hours. These tests were all made at

TABLE III

Length of time required for the germination of the spores of representative fungi

Authority*	Fungus	Hours necessary for germination
23	*Phytophthora infestans*, conidia	1–2
22	*Cystopus candidus*, conidia	2–10
40	*Plasmopara viticola*, conidia	3–12
37	*Venturia inaequalis*, ascospores	4
41	*Guignardia Bidwellii*, ascospores	36
13	*Endothia parasitica*, ascospores	6–12
39	*Didymellina Iridis*, pycnospores	18–36
	ascospores	6
5	*Pseudopeziza Trifolii*, ascospores	12
42	*Diplocarpon Rosae*, conidia	24
38	*Glomerella rufomaculans*, conidia	6–24
43	*Tilletia foetens*, chlamydospores	48
43	*Ustilago Hordei*, chlamydospores	6.5
43	*Ustilago Tritici*, chlamydospores	14–15
25	*Cronartium ribicola*, aeciospores	8–10
25	*Puccinia Antirrhini*, urediniospores	5–8
44	*P. Phlei-pratensis*, urediniospores	3
35	*P. Malvacearum*, teliospores	3
9	*Gymnosporangium Juniperi-virginianae*, teliospores	3–4
30	*Colletotrichum lagenarium*	10–24
45	*C. Schizanthi*	16–24
32	*Phyllosticta Antirrhini*	16–30
33	*P. Antirrhini*	18–24
11	*Cylindrocladium scoparium*	2–3.5
46	*Septoria Gladioli*	18

* Numbers refer to the literature cited.

the respective optimum temperatures for germination. Other tests were made at temperatures approaching the minimum and maximum temperatures for the germination of the spores of these fungi. Under these conditions, in every case, a longer time was required for germination than at optimum temperatures.

Oxygen relation.—It was observed that spores in the interior of a drop of distilled water never germinated as well as those on

the surface. The conidia of *Venturia inaequalis* germinated only when they were on or near the surface of the water. Teliospores of *Puccinia Malvacearum* did not produce sporidia when deeply submerged in the drop. But when distilled water was used, which had previously been aerated, equally good germination was secured whether or not the spores were submerged in the drops.

DeBary (47) described the behavior of spores in water between a cover glass and a glass slide. In this case, the spores

TABLE IV

Time period necessary for the germination of representative fungous spores under optimum conditions

Fungus and spores	No. of hours	Spores germinating (relative numbers)
Cronartium ribicola, Aeciospores	10 12	0 100
Cronartium ribicola, Urediniospores	5.5	100
Gymnosporangium clavipes, Aeciospores	4.0	100
Puccinia Malvacearum, Teliospores	2.0 3.0	Producing basidia 100. Producing basidiospores 0 Producing basidiospores 100
Sclerotinia fructigena, Conidia	5.0	100
Venturia inaequalis, Conidia	16.0 27.0	25 100

near the periphery of the cover glass germinate better than those near the center due to the relative amounts of air available. Duggar (3) found that a reduced oxygen supply retards spore germination. Blackman (48) noticed that if the germ tube of *Phragmidium violaceum* does not grow through the water and so reach the air it develops abnormally. Weimer (9) observed that when the teliospores of *Gymnosporangium Juniperi-virginianae* are covered with water they produce only long tubes instead of the normal promycelia and basidiospores. Melhus

and Durrell (7) found that when the urediniospores of *Puccinia coronata* are submerged only a small percentage of them germinate as compared with the number germinating when they float on a drop of water.

When spore germination tests were made in non-aerated distilled water, the writer secured best results by sowing the spores on the surface of the water rather than immersing them. Some spores, however, will not float. According to Duggar (3) the spores of many of the Phycomycetes and Hymenomycetes usually sink. The specific gravity of the spores of several Hymenomycetes determined by Buller (49) were between 1.02 and 1.21. Since some spores sink, all distilled water for germination studies should be aerated.

At this point reference should be made to the injurious effect of the presence of fungous spores on the germination of the spores of other fungi. Although the injurious effect of this competition between spores might be attributed to the secretion of toxic substances, there is little likelihood that this is the case. There is an indication that it is due to there being insufficient oxygen for all. The effect is much more marked in non-aerated than in aerated distilled water and is more marked in the interior of a drop of non-aerated distilled water than on its surface. All spores of Uredinales which the writer has observed germinate best when the drop of water in which they are contained is not contaminated by the presence of other fungous spores. When spores of *Alternaria*, *Colletotrichum*, or *Cladosporium* are present in a drop of water with the teliospores of *Puccinia Malvacearum*, the spores of the first three fungi may germinate but the teliospores of *Puccinia Malvacearum* do not germinate, although check teliospores in uncontaminated drops germinate perfectly. When in place of *Puccinia Malvacearum* the conidia of *Venturia inaequalis* were used a similar result was obtained; they germinated far better when no other spores were present with them in the drop of water. When there is lack of sufficient oxygen for all, only those spores which require the least will germinate. It was also observed that when relatively few spores of one species were present in a drop they germinated better than when the drop was crowded. This, too, may be attributed to insufficient oxygen. In all spore germination studies where optimum conditions are desired, an effort should be made to exclude from the culture drop the spores of all fungi except the

one under consideration, and there should not be present an excessive number of spores of that one fungus.

There are a few references which have come to the attention of the writer on the deleterious effect of competition or crowding on germinating spores. Edgerton (**50**) noticed that when more than twelve or fifteen spores of *Colletotrichum Lindemuthianum* are present in one cubic millimeter of water, they germinate more poorly than when a smaller number of spores are present. Taubenhaus (**51**) found it advisable to wash hollyhock leaves in water to remove the spores of saprophytic fungi preparatory to studying the germination of the teliospores of *Puccinia Malvacearum*. He does not indicate in what manner the presence of the spores of other fungi interfere with the germination tests.

Light relation.—Opinion in the literature is not unanimous as to the effect of light on spore germination. According to DeBary (**52**) and Farlow (**53**) light inhibits the germination of the spores of the Oomycetes. Cuboni (**54**) concluded that intense light interferes with the germination of the conidia of *Plasmopara viticola*. Ward (**55**) found that the spores of the brome rust germinate as readily in light as in darkness. Melhus (**22**) observed no difference in the percentage of conidia of *Cystopus canididus* germinating, nor in the time required for their germination, whether germination took place in light or darkness. Melhus (**23**) found that light does not interfere with the germination of the conidia of *Phytophthora infestans* if the optimum temperature for their germination is not exceeded. Duff (**17**) found that exposure to glass filtered sunlight is not injurious to the urediniospores of *Cronartium ribicola*, providing the temperature does not rise too high. He found that exposure to the ultra-violet rays from an electric arc completely inhibited spore germination. Lauritzen (**56**) concluded from his investigations that light is not a limited factor in the infection of plants by fungi.

The writer tested the effect of sunlight on the germination of the spores of *Alternaria Solani* and the conidia of *Sclerotinia fructigena*. The spores of both of these fungi germinate quite as well in sunlight, whether it be direct, diffuse, glass filtered or not glass filtered, as they do in darkness, provided that the conditions of temperature and moisture meanwhile remain near the optimum. The indications are that the spores of fungi

germinate in either light or darkness, when the other environmental conditions are between maximum and minimum limits. It is, however, probable that the germination of fungous spores in nature usually takes place in darkness, since it is in the night that conditions of temperatures and moisture nearer the optimum for germination usually prevail for a longer time.

Water relation.—An examination of the literature indicates that the moisture requirement of germinating spores is not uniform. Tulasne (57) was able to germinate teliospores of the Uredinales as well in a saturated atmosphere as in a drop of water. Patrigeon (20) found that for the germination of the conidia of *Plasmopara viticola* precipitated moisture is necessary and merely damp air is insufficient. According to DeBary (47) the spores of the Uredinales germinate better when they are merely in a moist atmosphere than when they are in water. Lesage (58) found that the spores of *Penicillium glaucum* can germinate in damp air so long as the humidity does not fall below 82 or 84 per cent. Taubenhaus (51) readily germinated the teliospores of *Puccinia Malvacearum* in a humid atmosphere. Levin (59) was able to infect tomatoes with *Septoria Lycopersici* by merely applying dry spores. Weimer (9) found the teliospores of *Gymnosporangium Juniperi-virginianae* unable to germinate when they were in contact with no moisture except that in the atmosphere. These spores did not germinate until the air became super-saturated, so that small drops of water collected on the slides in contact with the spores. Anderson (11) states that the spores of *Cylindrocladium scoparium* never germinate except when they are directly in water, a moist atmosphere being insufficient. According to Melhus and Durrell (7) the urediniospores of *Puccinia coronata* germinate only when they are in direct contact with water. Smiley (33) found that in the absence of a film of water, the spores of *Phyllosticta Antirrhini* do not germinate. Melhus, Durrell and Kirby (18) found that the sporidia of *Puccinia graminis* germinate profusely in drops of water, and but very poorly when their only moisture is obtained from the atmosphere.

The writer tested the effect of moist air as compared with precipitated moisture on the germination of the spores named in TABLE V. The aeciospores of *Gymnosporangium clavipes* germinate perfectly in moist air, as they do in water. The spores of *Alternaria Solani* and the conidia of *Venturia inaequalis* germinate

only 4 per cent in moist air as compared with 100 per cent in water. This means that in nature the relative number of spores of these two last named fungi germinating in moist air is very small, but undoubtedly sufficient to cause some infection. The conidia of *Sclerotinia fructigena* will not germinate in moist air but require precipitated moisture. The conidia of *Peronospora pygmaea* were also found to require precipitated moisture rather than moist air for their germination.

Of the spores studied by the writer and mentioned as above in the literature, in only five cases can they germinate well when their only source of moisture is the atmosphere. Three germinate very poorly in moist air. Six germinated only in precipitated moisture. The evidence is insufficient to warrant the conclusion that any group of fungi characteristically obtain their water for germination principally in the form of vapor. When optimum conditions for laboratory experiments on spore germination are

TABLE V

Effect of moist air as compared with precipitated moisture on the germination of fungous spores

Moisture conditions	Spore germinating (relative numbers)				
	A. Solani	*V. inaequalis*	*G. clavipes*	*S. fructigena*	*P. pygmaea*
In a drop of distilled water	100	100	100	100	100
On dry slide in moist chamber	4	4	100	0	0

to be obtained, water in the form of precipitated moisture rather than water vapor should be supplied. The question of too much water is probably closely related with the question of too little oxygen.

SUMMARY

1. The germination of the following spores was studied; conidia of *Venturia inaequalis* (Cke.) Wint., conidia of *Sclerotinia fructigena* (Pers.) Schrt., spores of *Alternaria Solani* (E. & M.) Jones & Grout, spores of *Botrytis cinerea* Pers., spores of *Rhizopus nigricans* F. de Wal., aeciospores of *Gymnosporangium clavipes* C. & P., and teliospores of *Puccinia Malvacearum* Mont.

2. Spores of parasitic fungi germinate better when obtained from the living host than when obtained from artificial media.

3. Mature spores can germinate through a broader range of environmental conditions than can immature spores.

4. Freshly mature spores can germinate through a broader range of environmental conditions than can old spores. As the spores age, viability at first decreases sharply after which it is only gradually lost. Longevity of spores is dependent on conditions of storage after detachment from the host. Moisture is of more importance than temperature in its effect on the length of life of the spore.

5. Spores of the Phycomycetes can germinate at the lowest minimum temperatures, followed in order by the urediniospores, the aeciospores, and the teliospores of the Uredinales. Aeciospores have the lowest optimum temperatures for germination followed in order by urediniospores, conidia of Phycomycetes, teliospores, and the spores of the Imperfect Fungi.

6. The nearer all conditions are to the optimum, the shorter the time required for spore germination.

7. Competition or crowding inhibits spore germination. This is attributed to insufficient oxygen.

8. Spores of the fungi studied germinated in either light or darkness.

9. Precipitated moisture is unnecessary for the germination of some spores if water vapor is available.

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Reviews, and papers that relate exclusively to foresty, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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BULLETIN

OF THE

TORREY BOTANICAL CLUB

DECEMBER, 1922

Miscellaneous notes on plants of Southern California—II*

PHILIP A. MUNZ AND IVAN M. JOHNSTON

LEMNA TRISULCA L.

Lemna trisulca L. Sp. Pl. 970. 1753.

This plant, reported by Abrams (Fl. Los Angeles 78. 1904) from Bear Valley in the San Bernardino Mountains and by Torrey (Pacific R. R. Rep. 4: 142. 1856) from San Gabriel Creek, has been collected by Miss G. Corwin at the mouth of Santa Ana Canyon near Mentone, where it was found in a ditch at about 2000 feet altitude. It is, therefore, apparently to be looked for at various points along the Santa Ana River

MICROSTYLIS MONOPHYLLOS (L.) Lindl.

Ophrys monophyllos L. Sp. Pl. 947. 1753.
Microstylis monophyllos Lindl. Gen. Sp. Orch. 19. 1830.

A few typical specimens of this species, *F. W. Peirson 2271*, were collected in marshy ground at 8000 feet elevation on the South Fork of the Santa Ana River in the San Bernardino Mountains, where they grew with such plants as *Gentiana simplex*, *G. humilis*, *Parnassia cirrata*, and *Luzula comosa*. This is the first collection west of the Rocky Mountains.

Phoradendron californicum var. **distans** forma **leucocarpum** Trelease forma nova

Like the variety *distans*, but having white berries.

[The BULLETIN for November (**49**: 313–348) was issued November 9, 1922.

*The first paper of this series was published in the BULLETIN for February, 1922 (**49**: 31–44).

TYPE: Twenty-nine Palms, southern edge of Mohave Desert, May 1, 1921, *Munz 4550*, (Baker Herb. 9547).

Very conspicuous as white-fruited clumps growing in bushes of mesquite with the typical red-fruited form. Specimens of this collection were sent to Dr. Wm. Trelease who considered it worth recognition and permitted us to publish it. A second collection, *Munz 4703*, likewise on mesquite, from Andreas Canyon near Palm Springs, can also be reported.

Eriogonum nodosum var. **Jaegeri** var. nov.

With habit, inflorescence, and floral structures of the typical form of the species but with stems tomentose only below on the leaf-bearing portion, the upper parts of the stem and the inflorescence being glabrous with, at most, a little wool in the axils. Involucres glabrous or slightly floccose, the subtending bracts woolly on their inner edges.

TYPE: Dry Morongo Wash, near Hole-in-the-Wall Springs, Riverside County, November 15, 1921, *E. C. Jaeger 251* (Baker Herb. 9424).

This glabrate form of *E. nodosum* Small (Bull. Torrey Club **25**: 49. 1898) was collected at the eastern base of the San Bernardino Mountains, between 2500 and 3000 feet altitude, and well deserves recognition because of the totally different aspect as compared with the typical form. It is reported as very plentiful by its finder, Mr. Edmund C. Jaeger, one of the most active collectors of the desert flora.

Eriogonum fasciculatum var. **flavoviride** var. nov.

With capitate inflorescence and general habits of the var. *polifolium* T. & G., but lower in stature, about one foot high; light green in color instead of ashy; leaves glabrous and green above, but somewhat tomentose and pallid below; calyx glabrous without and hairy within.

TYPE: Pinyon Wells, southern edge of Mohave Desert, April 30, 1921, *Munz 4505*, (Baker Herb. 9425).

This peculiar yellowish green glabrate plant was found to be abundant in a sandy desert canyon in high Lower Sonoran Zone above Pinyon Wells. It was associated all along the canyon with var. *polifolium*, but was very distinct from this in size and color. We have seen also material from Cottonwood Pass, *Hall 6003*, about fifteen miles to the southeast and in the same general mountain range; here too it grew with var. *polifol-*

ium but was smaller and earlier in anthesis. The relation of this glabrous variety to var. *polifolium* is analogous to that existing between typical *E. fasciculatum* and the pubescent var. *foliolosum*.

ALLIONIA PUMILA Standley.

Allionia pumila Standley, Contr. U. S. Nat. Herb. **12**: 345. 1909.

Allionia Brandegei Standley, *l. c.* 346.

The only *Allionia* hitherto reported from California is *A. Brandegei*, the type of which came from the Providence Mountains in the eastern part of the Mohave Desert. Two collections recently made by F. W. Peirson in the San Bernardino Mountains are of this species, which has recently been included in *A. pumila* by Standley (No. Am. Flora **21**: 226. 1918). These collections not only extend the range of this species to the western part of the desert but even into the coastal drainage. One (*Peirson 2257*) from the Santa Ana River, at 4500 feet elevation, is twice as tall as the type of *A. Brandegei* and has the leaves broadly ovate and cordate, rather than oblong and scarcely cordate. The other plant (*Peirson 1850*), from Cushenberry Grade, is more like Brandegee's type collection, being about ten inches high and with leaves ovate to oblong.

ALLIONIA NYCTAGINEA Michx.

Allionia nyctaginea Michx. Fl. Bor. Am. **1**: 100. 1803.

Allionia ovata Pursh, Fl. Am. Sept. 97. 1814.

The ovate-leaved form of the above species was found in June, 1919, to be locally established along a siding of the Santa Fe Railroad about a mile west of Upland, *Johnston 2169*. Examination of the locality in January, 1922, showed the colony to have been destroyed by the oil spray used by the railroad for weed destruction. This is apparently the first record for the state.

Scopulophila Rixfordii (Brandegee) comb. nov.

Achyronychia Rixfordii Brandegee, Zoe **1**: 230. 1890.

Scopulophila nitrophiloides Jones, Contr. W. Bot. **12**: 5. 1908.

Eremolithia Rixfordii Jepson, Fl. California 499. *f. 100.* 1914.

This odd desert plant seems to be generically distinct from *Achyronychia*, but Jones's *Scopulophila* has precedence over the much later generic name *Eremolithia* of Jepson.

Claytonia lanceolata var. **Peirsonii** var. nov.

As in the typical form of the species, but with peduncle and primary axis of inflorescence shortened so as to make the flowers appear umbellate.

TYPE: near Kelly's Cabin on Ontario Ridge, San Gabriel Mountains, at 8200 feet altitude, May 29, 1920, *F. W. & Mabel Peirson* (Baker Herb. 10524).

Known only from the eastern portion of the San Gabriel Mountains where, beside the type, we have seen a collection, *F. W. Peirson 2151*, from the Devil's Backbone at 7000 feet altitude. It is probable that this variety will necessitate a reconsideration of the status of *C. umbellata* Wats. (Bot. King Exp. 43. *pl. 6, f. 4–5.* 1871) of the northeastern part of California, for the principal character of that species is the same umbellate inflorescence that characterizes our variety. The new variety, however, may be told from *C. umbellata* by its shorter-petioled, broader leaves, which are widest below the middle (instead of above), and by its shorter stem, larger flowers, and isolated southern range.

THLASPI ARVENSE L.

Thlaspi arvense L. Sp. Pl. 646. 1753.

This crucifer, common in the Rocky Mountain region, can now be reported from Southern California (*F. W. Peirson 66*) at Henniger's Flats near Pasadena. The only other collection we have seen from California is by Chase from Adin, in Modoc County.

Draba corrugata var. **saxosa** (Davidson) comb. nov.

Draba saxosa Davidson, Bull. So. Cal. Acad. **19**: 11. 1920.

The phase of *Draba corrugata* that is found on San Jacinto Peak may well be deserving of a varietal name, but scarcely of a specific one. As pointed out in another paper (Johnston, Pl. World **22**: 88. 1919) the San Jacinto plant differs only in matters of degree and is closely simulated by some collections from the San Bernardino Mountains.

Sphaeralcea rosacea sp. nov.

A shrubby perennial forming loose clumps 10–15 dm. high; stems ashy, stellate-tomentose, slender, ascending, virgate; leaves remote, ovate- or oblong-cordate and somewhat three-lobed, doubly crenate, stellate-pubescent but greener above, blade usually 2–2.8 cm. long and 1.5–2.5 cm. wide, petioles 12–20 mm. long; inflorescence a very loose open panicle 2–4 dm. long, the ascending branches remote and one- to four-flowered; calyx stellate-tomentose, at anthesis 8–11 mm. high and 5–7 mm. wide, with lanceolate or oblong-lanceolate lobes, at fruiting 10–14 mm. long, bractlets setaceous, deciduous, 4–7 mm. long; pedicels 3–20 mm. long; petals pinkish when fresh but drying a rose-violet, 17–21 mm. long, claw densely villous-ciliate; fruit much depressed, stellate-pubescent; carpels one-seeded, about 3.5 mm. high, oblong in outline, sides smooth or at least not reticulate, seminiferous only below, the upper half thinner and scarious.

TYPE: Palm Springs, April 2, 1917, *Alice B. Chittenden* (Herb. Cal. Acad.).

A very ornamental species that is known to us only from the vicinity of Palm Springs, Riverside County, where it is a common plant in rocky ground in the canyons opening into the Colorado Desert. Besides the type we have seen a collection by Parish, No. 4109, and one by Johnston. This plant is the "purple-flowered form of *S. ambigua*," which is mentioned by Robinson (Synop. Fl. 1: 315. 1897) in his review of the genus. Though it has long passed as a form of *S. ambigua*, it is amply distinct and probably not even an immediate relative of that species, differing from it in habit and stature; in size, color and disposition of flowers; and in shape and texture of leaves. When we first saw the two species growing together, as they commonly do about Palm Springs, we never once thought of associating the two plants under one name; in fact, basing determination on superficial resemblances, the new species was taken to be a species of *Malvastrum*. The proposed species bears a considerable resemblance to certain of the shrubby malvastrums, having more or less woody stems and similarly colored flowers, but the technical characters of the carpels definitely ally it with *Sphaeralcea*.

VIOLA SHELTONI Torr.

Viola Sheltoni Torr. Pac. R. R. Rep. 4: 67. *pl.* 2. 1856.

Locally common on moist, shaded, oak-covered canyon-sides in the upper chaparral belt on the south slope of the San Antonio Mountains, where specimens have been collected in Charcoal Fork of Cucamonga Canyon, at 4200–4500 feet altitude, *Johnston 1303*, and near Brown's Flats, at 4200 feet, *Johnston 1759*. The specimens appear the same, character for character, as the common plant of Mendocino and Siskiyou Counties. The plant was known to range as far south as Mariposa County, where it was collected by Congdon, but between that station and the one in Southern California, which we now report, there lies a gap of over 280 miles in which the plant is not known to occur. This station for *V. Sheltoni* was announced as *V. lobata* by Johnston (Bull. So. Calif. Acad. **17**: 65. 1918).

OENOTHERA SPECIOSA Nutt.

Oenothera speciosa Nutt. Jour. Acad. Phila. **2**: 119. 1821.

Hartmannia speciosa Small, Bull. Torrey Club **23**: 181. 1896.

Well established along Chino Creek, from Pomona to near the confluence with the Santa Ana River. First collected several years ago by Johnston. Recently the following specimens have been collected near Pomona, all in moist soil along the stream: *Mrs. Lenington, Munz 4680, 4560*. These discoveries add a new species and subgenus of *Oenothera* to the flora of California. Our material is atypical in its rounded instead of obcordate petals and in being taller, some of the specimens attaining a height of four feet.

Oenothera cardiophylla var. **splendens** var. nov.

A large flowered variation with hypanthium two-thirds as long as the capsule and 20–25 mm. long; petals 15 mm. long.

TYPE: high among rocks at the foot of The Needles, Colorado River, March 7, 1910, *Grinnell* (Univ. Calif. Herb. 196590).

A very remarkable variation of the species and, because of its large flowers, probably of ornamental value. We know of but two collections, the one from The Needles by Grinnell and the other from the Chocolate Mountains by Childs. The foliage and habit of the plant are those characteristic of the species. No doubt some will consider this distinct enough for a species, but we are deterred from publishing it as such because of the immense amount of variation in the floral structures of

typical *O. cardiophylla*, of which this seems only to be a remarkable extreme.

CHIMAPHILA UMBELLATA (L.) Nutt.

Pyrola umbellata L. Sp. Pl. 396. 1753.
Chimaphila umbellata Nutt. Gen. **1**: 274. 1818.
Chimaphila occidentalis Rydb. No. Am. Flora **29**: 30. 1914.

This species can now be reported from Southern California, having been collected in the Dollar Lake region of the San Bernardino Mountains at 8750 feet altitude, *F. W. Peirson 829*. This discovery and that of *Pyrola picta* Smith, *Johnston 2860*, add two species of Pyrolaceae to the list prepared by Parish (Pl. World **20**: 247. 1917) for the San Bernardino mountains.

Asclepias eriocarpa var. **microcarpa** var. nov.

Follicles 3–4 cm. long; seeds 5 mm. long; coma 15 mm. long; pedicels 2–3.5 cm . long; in flowers and vegetative parts like the typical form of the species.

TYPE: North Fork of Deep Creek, San Bernardino Mountains, on a sunny hillside at 6000 feet altitude, July 17, 1921, *I. M. Johnston 2833* (Baker Herb. 9563.)

This variety is the form of the species frequent through the pine belt of the San Bernardino Mountains and differs from the typical form, which is not uncommon on the plains at the foot of the mountains, in its much smaller follicles. Many plants of the valley-inhabiting *A. eriocarpa* Benth. have been seen by the authors, but none have been noted which failed to have fruit much larger than in the variety here described. *A. eriocarpa* has follicles 8–10 cm. long on pedicels 4–6 cm. long, while the seeds measure about 8 mm. in length and have a coma 24 mm. long.

The small follicles can not be attributed to the blighting action of frost, for all produce perfect seeds and in all colonies seen the fruit was uniform in size and as here described. Further exploration may reveal the fact that the pine-belt form of *A. eriocarpa* found in the San Jacinto and San Gabriel Mountains is also referable to this variety; fruiting material from these ranges is lacking.

Phlox bernardina sp. nov.

Phlox dolichantha Brand; Engler, Pflanzenreich 4^{250}: 67. *f. 18, A-D.* 1907; Nels. W. Am. Phloxes 28. 1898; Milliken, Univ. Cal. Pub. Bot. **2**: 65. 1904. Not *P. dolichantha* Gray, Proc. Am. Acad. **22**: 310. 1887.

TYPE: in open pine forest, 6000 feet altitude, Bear Valley, June 1886, *Parish 1818*, (Univ. Calif. Herb. 194015).

The new species indicated here is the plant from the San Bernardino Mountains that has been known as *P. dolicantha*. The type of *P. dolichantha* Gray, however, came from the Pahrangat Mountains in southern Nevada and is evidently a form of what has been called *P. Stansburyi brevifolia* and *P. superba*. In the recent treatments of *Phlox* by E. Nelson, Milliken, and Brand, the plant from the San Bernardino Mountains has usurped the name of *P. dolichantha* to the exclusion of the original Nevada plants. *P. bernardina* differs from *P. dolichantha* and its immediate relatives in its very elongated corolla-tube, which is over four, instead of less than three, times the length of the calyx; in having its stems not shrubby below but herbaceous to the ground; and in its habitat, which is not at low altitudes in desert mountains but in the open pine forests of the San Bernardino Mountains. The new species is separated from its nearest relative by over 100 miles. It is known only from San Bernardino Mountains and appears to have been collected there in Bear Valley only.

NAMA HUMIFUSUM Brand

Nama humifusum Brand, Beiträge Hydrophyll. 9. 1911.

In Southern California this species has been known only from the three localities (Soldiers' Home, Los Angeles County, and Diamond Lake and Sweetwater Valley in San Diego County) given by Brand in the Pflanzenreich (4^{251}: 146. 1913); the plant, however, may be reported from Laguna Canyon in Orange County, where it was collected in May, 1919, *Munz, Street, & Williams 2681*.

LYCIUM SPENCERAE Macbride

Lycium Spencerae Macbride, Contr. Gray Herb. **53**: 18. 1918.

The type of this species proves to be a flowering specimen of *Prunus fasciculata* (Torr.) Gray (Proc. Am. Acad. **10**: 70.

1874). The identifying of this lycioid almond with *L. Spencerae* adjusts for local botanists the problem of explaining how so distinct a species, as this *Lycium* seemed to be, could so long go undetected in a locality so frequently visited as Cajon Pass. We are under obligations to Mr. F. Macbride for making at the Gray Herbarium the comparisons necessary for the establishing of the identity of the two species.

Penstemon Clevelandi var. **connatus** var. nov.

With habit of growth and flowers of the species, but with leaves jagged-serrate, usually glabrous and with at least the four upper pairs connate-perfoliate.

TYPE: near Van Deventers, southeastern base of the San Jacinto Mountains, June 1901, *H. M. Hall 2149* (Univ. Calif. Herb. 54999).

A very well marked variation that is apparently restricted to the eastern (Colorado Desert) base of the San Jacinto Mountains. Referable to this variety are the following: *Hall 1160* from the type locality, *Parish Bros. 1216* and *Johnston*, April, 1917, from near Palm Springs. The most evident relationship is with the variety *Stephensi* of the eastern Mohave Desert, the new variety agreeing in its foliar characters but differing in its somewhat smaller corolla and beardless sterile stamens. In our recent discussion of the var. *Stephensi* (Bull. Torrey Club **46**: 41. 1922) the specimens of *P. Clevelandi* Gray mentioned as simulating that variety in habit are in fact referable to var. *connatus*.

P. Clevelandi in its typical form occurs along the desert borders to the south of the range of the var. *connatus*. The northernmost locality seen for it is Coyote Canyon, *Hall 2766*. In the typical form the leaves are entire or rarely remotely dentate, never glaucous and are entirely free or, at most, only partially joined and not completely fused, with the suture line obliterated as in the variety.

Galium angustifolium var. **pinetorum** var. nov.

A low herbaceous perennial, stems 2–4 dm. high, simple, erect, tufted or arising from along short, prostrate, persistent, subterranean stems.

TYPE: Sierra Madre Mountains, Los Angeles County, 1893, *A. Davidson* (Univ. Calif. Herb. 28169).

A variety of the pine-belt and differing from the typical form of the species only in habit of growth. Additional specimens referable to this variety are the following: Santa Lucia Mountains, *K. Brandegee*, on the north, and Cuyamaca Mountains, *T. S. Brandegee*, July 7, 1894, on the south. Plants from the San Jacinto Mountains, *Hall 2509*, have the growth-habit of the variety, but are strictly branched and become 5–7 dm. high. The variety has been mentioned without a formal name by Johnston (Pl. World **22**: 118. 1919).

Galium Hallii sp. nov.

Dioecious perennial, shrubby at the base, with relatively few long (4–6 dm.) decumbent quadrangular stems, younger stems short-hispid, older stems glabrate and with a shiny exfoliating papery bark; leaves in fours, hirsute like the branchlets, light green, ovate-elliptical to elliptical, 5–11 mm. long, sessile, margins strongly revolute, midvein strong, lateral veins weak or absent; flowers borne in loose leafy clusters on the conspicuously and gracefully recurved tips of the branchlets, yellowish, about 2 mm. in diameter, bearing a few stiff hairs; fruit black, slightly juicy, body 3 mm. in diameter, covered with dense villous hairs of 2 mm. length.

TYPE: Coldwater Fork of Lytle Creek, San Gabriel Mountains, in gravelly ground at 5200–5700 feet altitude, July 7, 1918, *Johnston 2067* (Univ. Calif. Herb.).

Specimens examined: Coldwater Fork of Lytle Creek, San Gabriel Mountains, 5500 ft. alt. *Johnston 1667;* Lytle Creek, 5750 ft. alt., *Hall 1227;* Rock Creek Canyon, San Gabriel Mountains, *Abrams & McGregor 598;* Seymour Creek, Mt. Pinos region, 6700 ft. alt., *Hall 6505;* Tehachepi, 1889, *Greene;* Erskin Creek, 4–5000 ft. alt., *Purpus 5349,*

This is a remarkably clear-cut undescribed species of the *G. multiflorum*-alliance that has been confused with *G. multiflorum*, *G. stellatum*, and *G. occidentale;* from all of these it certainly differs and can be distinguished by its nodding flower-clusters. The plant has been recognized as distinct for several years, and the increasing material at hand seems to justify its description as a new species. It has been treated as "*Galium* sp." by Johnston (Pl. World **22**: 118. 1919).

The range is eminently a natural one, for the plant occurs at and just below the lower limits of the pine belt in the rocky canyons that open into the extreme western portion of the Mohave

Desert. The type locality, the southernmost known station, is almost on the Los Angeles—San Bernardino County line; from this point the range extends northward to Erskin Creek in the Sierra Nevada of Kern County.

It might be mentioned here that *G. occidentale* McClatchie (Erythea **2**: 124. 1894) is a trivial form of *G. californicum* H. & A., and that *G. grande* McClatchie (*l. c.*) is indistinguishable from *G. pubens* Gray. These identities are established by a study of authentic specimens.

BAHIA DISSECTA (Gray) Britton

Amauria dissecta Gray, Mem. Am. Acad. II. **4**: 104. 1849.
Bahia dissecta Britton, Trans. N. Y. Acad. Sci. **8**: 68. 1888.
Villanova dissecta Rydb. Bull. Torrey Club **37**: 333. 1910.
Amauriopsis dissecta Rydb. No. Am. Flora **34**: 37. 1914.

The first collection of this species to be reported from the state was made in the San Bernardino Mountains, *F. W. Peirson 2245*, along the Santa Ana River, at 6500 feet elevation, August 24, 1920.

POMONA COLLEGE
CLAREMONT, CALIFORNIA

Notes on Carex—XII

Kenneth Kent Mackenzie

1. An inland relative of a salt marsh sedge

The only representative of the *Ovales* which is an inhabitant of salt marshes, as far as I am aware. is *Carex hormathodes* Fernald, which is an abundant and characteristic species along the North American coasts from western Newfoundland to southeastern Virginia.* In 1902 attention was first drawn by Professor Fernald to an allied pla it found in fresh water swamps and reported by him as growing from Massachusetts to the District of Columbia. This was first treated by him as *Carex tenera* Dewey var. *Richii* Fernald, and later on as *Carex hormathodes* var. *Richii* Fernald.

In northern New Jersey this variety *Richii* is an abundant plant in places in swampy meadows, and with its graceful nodding heads is one of the most pleasing and attractive of our sedges. It is in every way a much more handsome plant than is *Carex hormathodes*. But not only does it have an entirely different habitat and a different appearance, but it has technical characters which are absolutely good. The perigynia have suborbicular bodies abruptly contracted into the beaks; the perigynia are loosely ascending or spreading in the spikes; the terminal spike is abruptly contracted at base below the perigynia, and the staminate portion is conspicuous; and the spikes are scattered in a very flexuous head. In *Carex hormathodes* on the other hand the perigynia have oblong-ovate bodies much less abruptly contracted into the beaks; the perigynia are appressed; the terminal spike tapers at base, and the staminate portion is short; and the upper spikes are approximate. The

* The inland reports for this species are all erroneous, as also are the reports of its occurrence from further south than southeastern Virginia. It however is to be expected at least as far south as North Carolina. The var. *invisa* (Boott) Fernald represents nothing but stunted specimens.

differences between the two species are well brought out in the figures (No. 356–8) in Gray's Manual.

In proposing specific rank for this plant I am glad to say that I have the cordial support of Professor Fernald and Mr. Bayard Long, both of whom are well acquinted with it in the field.

Carex Richii (Fernald) Mackenzie sp. nov.

Carex tenera Dewey var. *major* Olney, Exsicc. fasc. 2, No. 15 (in part). 1870.

Carex tenera var. *Richii* Fernald, Proc. Am. Acad. **37**: 475. 1902.

Carex hormathodes Fernald var. *Richii* Fernald, Rhodora **8**: 166. 1906.

Densely cespitose, the rootstocks very short-prolonged, black, fibrillose, the culms 6–10 dm. high, erect, but very slender to base, nodding, sharply triangular, very rough beneath head, exceeding the leaves, dark brownish at base and clothed with the dried-up leaves of the previous year, the lower bladeless; leaves of the year two to four to a culm, on lower fourth, but widely separate, the lower nodes often exposed, the blades flat, 1.5–2.5 mm. wide, usually 1–3 dm. long, long-attenuate, the sheaths green striate ventrally nearly to mouth, the ligule surrounding the culm, short-prolonged beyond base of blade; spikes four to eight, strongly separate in a moniliform, flexuous head, gynaecandrous, the staminate flowers conspicuous, tapering clavate or in the terminal truncate clavate at base, the pistillate part orbicular to ovoid-orbiculur, 6–12 mm. long, 6–9 mm. wide, rounded at apex, and with some twenty to thirty spreading or spreading-ascending perigynia with conspicuous tips; lower bracts setaceous, prolonged, the upper scale-like; scales lanceolate, hyaline and yellowish-brown tinged, acuminate or aristate from the sharp midvein, shorter and much narrower than the perigynia; perigynia very flat and thin except where distended by achene, membranceous, greenish, or in age straw-colored, 4–5 mm. long, 2.5 mm. wide, the body suborbicular, widest near middle, strongly winged to base, serrulate above middle, finely about 10-nerved on either side, round-truncate and sessile at base, abruptly contracted into the flat, serrulate, red-tipped, obliquely cut dorsally at length bidentate beak, more than half length of body; achenes lenticular, stipitate, oblong-obovoid, 1.5 mm. long, 0.75 mm. wide, yellowish-brown, apiculate; style slender, obscurely jointed with achene; stigmas two, reddish, slender, short.

SPECIMENS EXAMINED*

MASSACHUSETTS: Middleboro, *Murdoch*, June, 1900 (N.E.) Canton, *Churchill*, June 17, 1900 (N.E.); Dover, *Winslow*, June 21, 1912 (N.E.); Dedham, *Forbes*, June 10, 1912 (N.E.); Stony Brook Reservation, *Kidder*, June 14, 1920 (N.E.); Sudbury, *Rich et al. 99* (TYPE), June 17, 1902 (N.E., H., P., N. Y., K.M.); Bedford, *Murdoch*, June 7, 1902 (N.E.); Weston, *Weatherby*, June 20, 1909 (N.E.); West Cambridge, *Pease 3084*, May 27, 1903 (N.E.); South Sudbury, *Miss Carr*, June 30, 1897 (N.E.); Cambridge, *Beal* (H.), also *Hubbard*, June 2, 1896 (N. E.), also *Deane*, June 8, 1887 (H.), also *Fernald*, June 10, 1891 (Col.); Stoneham, *Rich*, June 5, 1894 (N.E.); Reading, *Perkins*, June 14, 1883 (N.E.), also *Manning*, June 8, 1882 (N.E.); Arlington, *Wm. Boott*, June 5, 1870 (H.); Mystic Pond, *Wm. Boott*. June 5, 1870 (H.); Amesbury, *Eaton*, June 1, 1903 (H.); Sherborn, *Loomis 1033*, June 19, 1912 (K.M.).

RHODE ISLAND: Providence, *Olney* (N.Y.).

CONNECTICUT: Waterbury, *Blewitt*, June 15, 1911 (N.E.), also *1287*, June 10, 1912 (N.E.); South Windsor, *Woodward*, June 28, 1909 (N.E.); Columbia, *Weatherby 4090*, June 26, 1917 (N.E.); Thompson, *Weatherby 4114*, July 1, 1917 (N.E.); Pomfret, June 5, 1871 (N.Y.); Newington, *Wright*, May, 1879 (H.); Sprague, *Graves*, June 13, 1902 (H.); Griswold, *Graves*, June 16, 1899 (H.); Killingly, *Bissell*, June 22, 1902 (H.); Thompson, *Bissell*, June 22, 1902 (H.); Oxford, *Harger*, June 5, 1904 (H.), also *4262*, June 11, 1905 (P.); East Hartford, *Weatherby*, May 25, 1903 (H.); Milford, *Eames 5120*, June 24, 1904 (K. M., H.);

NEW YORK: Junius, *Sartwell* (H.).

NEW JERSEY: Closter, *Austin* (H.); Newark, *Livingston 35*, May 27, 1894 (H.); Crosswick's Creek, *Britton*, May 29, 1904 (N. Y.); Passaic River, Bergen County (N.Y.); Oradell, Bergen County, *Mackenzie 759*, June 19, 1904 (K.M.); Stirlington, Morris County, *Mackenzie 1267*, May 28, 1905 (K.M.); Mon-

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* Specimens are cited from herbaria as follows: Columbia University (Col.); Gray Herbarium, Harvard University (H.); K. K. Mackenzie (K.M); New England Botanical Club (N.E); New York Botanical Garden (N.Y.); New York State Museum (Albany); Philadelphia Academy of Natural Sciences (P.).

mouth Junction, *Mackenzie 4963*, May 26, 1912 (K.M.); Succasunna, *Mackenzie 4128*, June 13, 1909 (K.M.); Delanco, Burlington County, *Long 3474*, May 19, 1910 (P.); Centre Square, *Brinton*, May 20, 1892 (P.); eight miles southwest of Mickleton, *Heritage*, May 25, 1892 (P.); Budd's Lake, Morris County, *Heritage*, May 28, 1895 (P.).

PENNSYLVANIA: Easton, *Garber*, 1868 (P.), also *Porter*, June 5, 1890 (P.); Lehigh Gap, Lehigh County, *Pretz 1831*, May 20, 1909 (P.); Slatington, Lehigh County, *Pretz 10182*, June 6, 1920 (P.), also *Bachman 2132*, June 1, 1911 (P.); Strassburg, Lehigh County, *Pretz 3355*, May 20, 1911 (P.); Cementon, Lehigh County, *Pretz 10131*, May 30, 1920 (P.); Rockhill, *MacElwee*, May 31, 1903 (P.); Quakertown, Bucks County, *Martindale* (P.); Sellersville, *Pretz*, May 25, 1884, June 1, 1888, and May 26, 1896 (P.), also *Crawford*, June 1, 1989 (P).; Penn Valley, Bucks County, *Crawford*, June 1, 1899 (P.); Tullytown, *Crawford & Brown*, 1902 (P.); Byberry, *Martindale*, June, 1864 (P.); Wissahickon, *A. H. Smith* (P.); Sugartown, Chester County, *Pennell & Long 7628*, June 26, 1912 (P.); Nottingham, Chester County, *Pennell & Long 7483*, June 22, 1912 (P.); Mercersburg, Franklin County, *ex herb. Porter*, May 25, 1847 (P.); Wyoming Valley, *Thurston*, 1892 (P.); Elk County, *McMinn*, 1868 (P.).

DELAWARE: Wilmington, *Commons*, June 30, 1896 (P.); Vandyke, Newcastle County, *Long* May 24, 1909 (P.); Townsend, *Commons*, May 17, 1883 (P.).

INDIANA: Palmyra, Harrison County, *Deam 23417*, June 4, 1917 (K.M., H).

2. A SEGREGATE FROM CAREX ALBOLUTESCENS

Among the varieties of *Carex straminea* Willd. recognized by Professor Bailey was var. *cumulata* Bailey, based on specimens collected in Pennsylvania by Porter, in New Brunswick by Fowler and on the Saskatchewan Plains by Macoun. This variety, proposed in 1889, was maintained by Bailey in 1890 in the 6th Edition of Gray's Manual (p. 622), where its distribution was given as from Pennsylvania to New England and northward. It was said to be rare and to grow in dry grounds. Three years later in 1893 Professor Bailey placed the plant under *Carex albolutescens* Schw., as a variety, but added noth-

ing to his previous publications concerning its distinguishing characters or range; and this treatment is followed by Kükenthal in the Pflanzenreich (4^{20}: 209). By other authors Professor Bailey's name has been treated as a synonym of *Carex albolutescens*.*

As shown however by the large number of specimens of Bailey's variety which have been collected in recent years, it not only has an entirely different range from *Carex albolutescens* but it has several constant and well-marked points of difference, and is clearly entitled to specific rank. It is a northern species ranging from Saskatchewan to New Brunswick and south to Massachusetts, Connecticut and northern Pennsylvania. It occurs in a great variety of habitats varying from wet to dry, but seems able to thrive in much drier places than can *Carex albolutescens*. In the southern part of its range it seems only to be recorded from the higher elevations. It is not a coastal plain plant like *Carex albolutescens*, but like that species is not a species of limestone areas.

As above stated *Carex albolutescens* is typically a coastal plant. It reaches its northern limit in eastern Massachusetts but has a very extensive range to the south, being found as far south as northern South America. In the more southern part of its range it gets into the mountains.

The best technical character to separate the northern plant from *Carex albolutescens* is that in it the perigynia are nerveless ventrally, while in *Carex albolutescens* they are strongly several-nerved. But in addition to this the spikes are numerous (five to thirty) and densely aggregated; the green perigynia are more conspicuous than in *Carex albolutescens*, thus giving the heads a characteristic heavy, green, or in age brownish, appearance; the sheaths are looser, and the leaf-blades of the sterile culms are usually wider, being 4–5 mm. in width; in developed plants the lateral spikes also are truncate-rounded at base.

Carex albolutescens has fewer spikes (three to ten), which are less densely aggregated; and the heads have a very characteristic silvery-green appearance; its sheaths are tighter than in the northern plant and the leaf-blades of the sterile culms are

* The perigynium and the heavily spiked head, figured in the seventh edition of Gray's Manual (*f. 351*) as *Carex albolutescens*, represent Bailey's plant, and the head with five spikes represents genuine *Carex albolutescens*.

normally narrower and but 2.5–3 mm. in width (although occasionally more); and the lateral spikes are round-tapering at base.

The northern plant is evidently abundantly distinct and it should be treated as

Carex cumulata (Bailey) Mackenzie sp. nov.

Carex alata Torr. var. *pulchra* Olney (mostly), Exsicc. fasc. 2, No. 23 (also Bailey Proc. Am. Acad. **22**: 150 as synonym). 1871.

Carex straminea Willd. var. *cumulata* Bailey, Mem. Torrey Club **1**: 23. 1889.

Carex albolutescens Schw. var. *cumulata* Bailey, Bull. Torrey Club **20**: 422. 1893.

Very densely cespitose, the rootstock not prolonged, the culms 3–9 dm. high, stiff, sharply triangular, roughened beneath head, brownish at base and clothed with the dried-up leaves of the previous year, the lowest bladeless; leaves of the year with well-developed blades two to four to a culm, on lower third but not bunched, the lower nodes sometimes exposed, the blades flat, light-green, thickish, erect or ascending, 3–5 mm. wide, 7–25 cm. long, roughened towards apex, the sheaths loose, strongly green striate ventrally and conspicuously prolonged beyond base of blade and continuous with the ligule; sterile shoots elongated, the blades usually 4–5 mm. wide, occasionally narrower, erect, the sheaths very loose; spikes five to thirty, gynaecandrous, very closely aggregated into an ovoid or oblong head 2–4 cm. long, 1–2 cm. thick, the spikes ovoid, 6–10 mm. long, 5–8 mm. thick, short-pointed at apex, the lateral truncate or rounded at base, the terminal clavate, greenish appearing or in age brownish, closely many-flowered, the perigynia ascending with appressed green tips; lowest bract cuspidate prolonged, often conspicuous; scales ovate, obtuse or acute, much narrower and shorter than the perigynia, white-hyaline with one- to three-nerved green center; perigynia thin, plano-convex, 3–4 mm. long, 2.5 mm. wide, membranaceous, greenish or in age brownish, the body orbicular-obovate, widest at top, round-tapering and sessile at base, wing-margined nearly to base, serrulate above the middle, nerveless ventrally, lightly several-nerved dorsally, very abruptly contracted into the short, serrulate, flat, obliquely cut dorsally beak about 0.75 mm. long, about one-third to one-fourth the length of the body; achenes lenticular, oval-obovoid, at maturity yellowish brown, very short substipitate, 2 mm. long, 1.25 mm. wide, bent-apiculate; style slender,

jointed with achene, at length deciduous; stigmas two, slender, light-reddish, short.

SPECIMENS EXAMINED

NEW BRUNSWICK: Bass River, *Fowler*, August 9, 1872 (H, N.Y.); Miramichi, *Fowler*, August 24, 1894 (H.), also *Williams & Fernald*, July 25, 1902 (H.); Kent County, *Fowler* (TYPE), July 1870 (H., N.Y., Col. Albany, P.).

NOVA SCOTIA: Bell's Island, Lahave River, *Macoun 82518*, August 10, 1910 (H.); Bridgewater, *Macoun 82519*, July 18, 1910 (H.); Springhill Junction, *Pease & Long 20309*, July 18, 1920 (K.M.); Port Mouton, *Fernald & Graves 20312*, August 18, 1920 (K.M.); Middleton, *Fernald et al. 20325*, July 20, 1920 (K. M.); Broad River, *Fernald & Bissell 20311*, August 16, 1920 (K.M.).

MAINE: Somesville, *Fernald*, September 22, 1892 (N.E.,H.); Bangor, *Knight*, August 7, 1904 (H.); Pembroke, *Fernald 1439*, July 17, 1909, (N.E., H.); Southport, *Fernald*, August 1 and 2, 1894, (N.E., H); Kennebunk, *Parlin 867*, August 26, 1897 (H., N.E.); Mt. Desert Island, *Greenleaf*, August 3, 1883 (N.E.), also *Rand*, *Redfield*, *Faxon*, *Fernald*, *Williams*, numerous collections 1890–1898 (H., N.E., Col., N.Y.); Milford, *Fernald & Long 12928*, August 25, 1916 (N.E.); Lovell, *Pease 17307*, August 30, 1918 (N.E.); Matinicus, *C. A. E. Long*, August 28, 1919 (N. E.); summit of Mt. Battie, 1325 feet, *Furbish*, July 14, 1903 (N.E.), also *Bissell*, August 13, 1913 (N.E.); Durham, *Dinsmore*, August, 1898 (N.E.); Bear Mountain, Livermore, *Furbish*, July 24 and 25, 1896 (N.E.); Kennebunk, *Deane*, July 5, 1894 (N.E.); Berwick, *Parlin 1062*, July 24, 1898 (N.E.); North Berwick, *Fernald*, July, 1897 (N.E.).

NEW HAMPSHIRE: Nottingham, *Eaton*, June 20, 1900 (H.); Mt. Monadnock, 3000 ft., *Harper*, July 3, 1899 (N.E.), also "*A. W. D.*," August 7, 1916 (N.E.).

MASSACHUSETTS: Mt. Watatic, Ashby, *Knowlton*, August 9, 1908 (H.); Medford, *W. Boott*, June 30, 1861, (N.E.); July 25, 1863 (H.); Edgewith, *W. Boott*, July, 1853 (H.); Ashland, *Morong*, July 10, 1879 (H.); West Manchester, *Hubbard 195*, October 11, 1911 (N.E.); Middlesex Falls, *Kidder*, June 28, 1920 (N.E.); Wilmington, *Collins*, June 25, 1887 (N.E.); Mt. Washington, Berkshire County, *Hoffman*, August 23, 1914

(N.E.); Lake Undine Dome, Berkshire county, *Hoffman*, August 27, 1902 (N. E.).

CONNECTICUT: East Windsor Hill, "*A. W. D.*", August 26, 1915 (N.E.); South Windsor, *Bissell*, July 30, 1916 (N.E.); also *Blewitt 1502*, July 10, 1912 (N.E.), also *3470*, August 8, 1917 (P.).

NEW YORK: Taghkanick Range, *Hoysradt*, July-August (H.); Karner, Albany County, *House, 6410*, July 7, 1919 (Albany); Whitestown, Oneida County, *Haberer 3760*, August 22, 1912 (Albany); Ft. Ann, Washington County, *Burnham 49*, June 19, 1892 (N.Y.); Sams Point, alt. 2600 ft., *Rusby*, August 20, 1896 (Col.); Mt. Riga, *Hoysradt*, July 17, 1878 (Col.).

PENNSYLVANIA: Naomi Pines, *Porter*, July 1, 1893 (P.), also *Britton*, July 2, 1893 (Col.); Pocono Plateau, *T. Greene*, September 4, 1861 (P.), also *Porter*, September 11, 1869 (P.), July 25, 1881 (P.), August 6, 1891 (Col., H.), and July 1, 1893 (P.).

MICHIGAN: Alger, *Wheeler*, July 2, 1895 (H.); Omer, Arenac County, *Wheeler*, July 24, 1902 (H.); Duck Lake, Arenac County, *Wheeler*, 1900 (H.); Township 18, n. 4 E., Section 24, *Wheeler*, August 8, 1900 (H.); Township 19, n. 6 E., Section 16, *Wheeler*, August 9, 1900 (H.); Emerson, Chippewa County, *Dodge*, August 28 and September 4, 1914, (K.M.); Manistique, Schoolcraft County, *Dodge*, September 22, 1915 (K.M.); Alpena, *Wheeler*, July 8, 1895 (H., Col.).

ONTARIO: Lake of the Woods, *Macoun 33*, July 28, 1872 (H.).

SASKATCHEWAN: Fort Ellice, *Macoun 219*, 1872 (H.).

3. A NORTHERN RELATIVE OF CAREX BREVIOR

In the northern part of the United States from Maine to Michigan and in southern Canada from Ontario to Manitoba, there is found a large, robust and handsome member of the *Ovales*. It has five to ten spikes, which normally are well separated, but plants with approximate or subapproximate spikes are not uncommon. It is the plant treated by Professor Fernald as *Carex festucacea* Sc1k. (Proc. Am. Acad. 37: 477. *pl. 3, f. 47–48*), and also so treated in Gray's Manual (7th ed., p. 221. *f. 363*). To it is added in the treatments referred to a variety *brevior* (Dewey) Fernald, distinguished by having but three to six approximate or subapproximate spikes.

When I prepared the article on *Carex* for the second edition of Britton & Brown's Illustrated Flora, I treated these two plants together, because the number of heads and their degree of separation was not a constant character. Later, in a paper on *Carex straminea* and its allies (Bull. Torrey Club 42: 603. 1916), it was pointed out that the genuine *Carex festucacea* was a different plant than either of the above, and the name *Carex brevior* (Dewey) Mackenzie was applied to what I had treated as *Carex festucacea* Schk. in the Illustrated Flora.

In the meantime Kükenthal (Pflanzenreich 4^{20}: 207), noticing the close general resemblance of Fernald's *Carex festucacea* to *Carex Bicknellii* Britton (*Carex straminea* var. *Crawei* Boott), cited it under his treatment of that plant.

A detailed study has disclosed that the large northern plant here under discussion has characters which are constant in a very considerable series of specimens. As compared with *Carex brevior* it has the perigynia appressed-erect instead of spreading-ascending. The mature perigynia are membranaceous and strongly pellucid-puncticulate. They entirely lack the firm coriaceous texture so characteristic of *Carex brevior* and are also more nerved than in that species. These differences are well brought out in Fernald's figures above referred to, even the difference in the texture of the perigynia coming out.

The culms of the northern plant are much developed the first year of their growth, and the old dried leaves towards the base of the culm are therefore very marked in the flowering year. In *Carex brevior* on the other hand the development the first year is much less, and the dried leaves are short and rather inconspicuous in the flowering year. The sheaths too in the northern plant are white-hyaline ventrally for but a short distance, while in *Carex brevior* this feature is very strongly developed, and they also differ from those of the latter plant in being strongly papillate dorsally. As stated by Fernald the northern plant has five to ten spikes which normally are distinct and well separate, and *Carex brevior* usually has fewer spikes which are approximate or sub-approximate. However, this is but a well-marked tendency and specimens of the northern plant with a congested head or *Carex brevior* with spikes as widely separated as in the northern plant are not uncommon. *Carex Bicknellii* can be readily distinguished by its larger

(5.5–7.5 mm. long), nearly translucent perigynia, which are strongly about ten-nerved ventrally, and very strongly winged. It is, I would say, more closely related to the northern plant than is *Carex brevior*.

A real understanding of the members of the *Ovales* found in the northeastern part of North America and the characters which separate them dates from Professor Fernald's revision of the group in 1902. The plant which I have been here discussing is one which he has collected on a number of occasions. It is therefore one to which it is highly fitting to give his name. Unfortunately there is a poorly understood Japanese species to which his name has been given. Under the circumstances I trust that I will be pardoned in proposing for the plant I have been discussing a longer name than would ordinarily be desirable.

Carex Merritt-Fernaldii Mackenzie sp. nov.

"*Carex festucacea* Schkuhr" Fernald, Proc. Am. Acad. **37**: 477. *pl. 3, f. 47–8.* 1902.

Cespitose from short-prolonged, lignescent, black-fibrillose rootstocks, the culms 3–10 dm. high, slender but stiff, sharply triangular above, terete towards base, strongly biennial, exceeding the leaves, smooth or very slightly roughened beneath head, conspicuously clothed at base with the short -bladed leaves of the previous year, the lower bladeless; leaves with well-developed blades three to six to a culm, on the lower third but not bunched, the blades erect-ascending, dull- or yellowish-green, firm, 1.5–3 mm. wide, usually 1–2 dm. long, strongly roughened towards apex especially on the margins, the sheaths tight, white-hyaline ventrally for a short distance below mouth only, strongly papillate dorsally, extending up beyond point of insertion of blade and continuous with ligule, the latter longer than wide; spikes four to ten (usually six to eight), aggregated to separate, the head 1.5–8 cm. long, 7–15 mm. wide, the spikes gynaecandrous, subglobose to ovoid, 7–15 mm. long, 5–9 mm. wide, with fifteen to thirty appressed-ascending perigynia above (the beaks appressed-ascending), blunt at apex, abruptly contracted into the short clavate basal staminate portion; bracts scale-like, the lowest often prolonged, 1–4 cm. long, the upper merely acuminate or short-awned; scales ovate, obtuse to short-cuspidate, yellowish brown with three-nerved green center and narrow hyaline margins, shorter and much narrower than the perigynia above; perigynia suborbicular, 4–5 mm. long, 2.5–3.5 mm. wide, concave-convex, thickish over the achene but the walls membran-

aceous, strongly pellucid-puncticulate, yellowish-green or in age yellowish-white, strongly winged to base, serrulate to below middle, truncate rounded at base, strongly several to many nerved dorsally, nerveless to three to five-nerved ventrally, often only towards base, the wings one- to two-nerved, abruptly narrowed into the flat, serrulate, reddish-brown tipped, obliquely cut dorsally, bidentate beak, about 1 mm. long and less than one-third length of body, the margins of the orifice reddish-brown; achenes lenticular, 1.75 mm. long, 1.5 mm. wide, substipitate, apiculate, brown, shining; style slender, straight, jointed with achene, deciduous; stigmas two, reddish brown, slender, long.

TYPE LOCALITY: Orono, Maine, *Fernald*, July 3, 1897 (TYPE in the Gray Herbarium of Harvard University).

SPECIMENS EXAMINED

MAINE: Seal Harbor, *Redfield*, July 14, 1890 (H., N.E., P.), also *Williams* July 25, 1890 (N.E); Canton, *Parlin 2021*, August 8, 1906 (H.); North Berwick, *Parlin 798*, July 15, 1897, also May 1892 (H.); Mt. Desert Island, *Rand*, July 9, 1893, also July 15, 1894 (H.); Basin Mills, *Knight*, July 15, 1904 (H.); Orono, *Fernald*, June 1, 1899 (N.E.), July 14, 1890 (N.E.), July 12, 1897 (N.E.), July 2 and 3, 1897 (H.); Bumford Point, *Parlin*, July 4, 1890 (H.); Canton, *Parlin* 1972, July 10, 1906 (H.), also *2275*, 1907 (H.); Tatnic, *Parlin*, July 11, 1891, also June 1892, (N. E., H.); Orono, *Fernald & Long 12953*, July 22, 1916; (N.E., P.); Milford, *Fernald & Long 12955*, August 25, 1916 (N.E., P.); Farmington, *Knowlton*, July 9, 1911 (N.E., P.); Woodstock, *Pease 17126*, July 11, 1918 (N.E.); Canton, *Parlin 2094*, June 25, 1907 (N.E.); Dixfield, *Parlin 2461*, June 28, 1908 (N.E.); Gilead, *Pease 16013*, July 5, 1914 (N.E.); Rumford Point, *Parlin*, July 4, 1890 (N.E.); Dennysville, *Fernald 1444*, July 19, 1909 (N.E.); Columbia, *Knowlton*, August 4, 1916 (N.E., P.); West Pembroke, *Fernald 1452*, July 6, 1909 (N.E.); Big Hill, *Fernald 1438*, July 17, 1909 (N.E.); Leeds, *Knowlton*, July 23, 1916, (N.E., P.); New Gloucester, *Knowlton*, July 25, 1920 (N.E.); Baldwin, *Fernald et al. 12956*, August 30, 1916 (N.E., P.); Kennebunkport, *Deane*, July 12, 1894 (N. E.); North Berwick, *Parlin 798*, July 15, 1897 (N.E.); Alfred, *Fernald & Long, 12954*, August 10, 1916 (N.E., P.); Wells, *Fernald & Long 12952*, August 8, 1916 (N.E., P.); North Ber-

wick, *Parlin & Fernald*, June 13–14, 1896 (N.E.); Tatnic Hill, *Parlin & Fernald*, June 13–14, 1896 (N.E.); Cape Porpoise, *Furbish*, July, 1901 (N.E.); South Berwick, Parlin, July 31, 1896 (N.E.); Hermon, *Knight* 5035, June 30, 1906 (K.M.); Veazie, *Knight*, July 15, 1905 (K.M.).

NEW HAMPSHIRE: Troy, *Rand & Robinson 507*, June 13, 1898 (H.); Shelburne, *Deane*, July 8, 1914, also July 30, 1914 (N.E., P.); Plymouth, *Fernald, 11589*, July 30, 1915 (N.E.); Durham, *Knowlton*, July 1, 1917 (P.).

VERMONT: Mason Hill, Pownal, *Churchill*, June 18, 1901 (N.E).

MASSACHUSETTS: Amherst, *B. P. Clark*, June 6, 1881 (P.).

NEW YORK: Wellesley Island, Jefferson County, *Robinson & Maxon 1*, June 28, 1902 (H.); Thousand Island Park, *Ball*, July 1904 (K.M.); Middle Grove, Saratoga County, *Peck* (Albany); East Galway, Saratoga County, *E. A. Burt* (Albany); West Ft. Ann, Washington County, *Burnham*, June 27, 1918 (Albany).

ONTARIO: Lake Nipigon, *John Macoun*, July 11, 1884 (H.); Kingston, *Klugh*, June 30, 1906 (H.); "Portage River, Lake Superior", *ex herb. C. E. Smith*, August 3, 1865 (P.).

MICHIGAN: Washington, *ex herb. Dewey;* Herb. (H.); Kewenaw County, *Farwell* 762, August 1890 (H.); Muskegon, *McClatchie 48* (H.); Douglas Lake, Emmet County, *Ehlers, 296, 299*, July 17, 1920, also *L. E. Smith 1*, July 3, 1917 and 159, Aug. 20, 1917(K.M.); Clifton, *Farwell*, July 18, 1890 (Albany); Isle Royale *Williamson, 2276* August 15, 1912 (P.).

MANITOBA: Lake Winnipeg Valley, *Bourgeau* 1857 (H.).

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ADDENDUM

After the above was written, and when on a visit to the Philadelphia Academy of Sciences, Mr. Bayard Long asked me to look at the type specimen of *Carex albolutescens* Schw. preserved there. It was apparent that it was a young and immature specimen of the genuine *Carex straminea* Schk. as interpreted by me (Bull. Torrey Club **42**: 605–6), a conclusion which Mr. Long had himself arrived at. The previous identification of the plant

of Schweinitz with the plant treated in this article and generally as *Carex albolutescens* can be readily understood. The two species really stand next to each other, and as long as genuine *Carex straminea* was not understood and kept separate, it was a natural thing to do to identify the plant of Schweinitz in the way that was done. The name, however, has always been inappropriate, and one is glad to be able to reduce it to synonymy.

It now appears that the plant treated in this article and generally as *Carex albolutescens* ("*Carex albolutescens* Schw." Kükenth. in Engler, Pflanzenreich **4**[20]: 208; Mackenzie in Britton & Brown, Ill. Fl. (2d. ed.) **1**: 385. *f. 941* [excluding var. *cumulata* Bailey]; Robinson & Fernald in A. Gray Man. (7th. ed.) 219. *pl. 351* [left hand] excluding var. *cumulata* Bailey; "*Carex foenea* Willd." Boott, Ill. Carex **3**: 118, *pl. 375*) is without a name. It therefore gives me much pleasure to be able to name it for that excellent field man and acute student, Mr. Bayard Long, as **Carex Longii.** A specimen collected July 24, 1907, by Mr. Long at Cold Spring, Cape May County, New Jersey, and preserved in the herbarium of the Philadelphia Academy of Natural Sciences is designated as the type.

Stimulation of plants by carbon disulphide

Carrie Oldenbusch

The problem of stimulation of plants by minute doses of chemicals, which are poisonous in higher concentrations, has long been an interesting one. Raulin (1) in 1869 was probably the first to undertake work of this kind, using a nutrient solution made up of a large number of substances as a culture medium. As the stimulant, Raulin added to his nutrient solution small amounts of metallic salts, such as silver nitrate, platinum dichloride, or copper sulphate, and found that cultures of *Aspergillus niger*, grown in these solutions produced a more luxuriant mycelium than cultures to which nothing had been added. Pfeffer (2) in 1895, by means of comprehensive experiments, determined that such a complicated nutrient solution was unnecessary and originated a number of solutions which have been and are still extensively used in work of this kind. Benecke (3), in the same year, published a paper in which he also gave a much simpler normal solution than Raulin's but slightly different from Pfeffer's.

Richards (4), using the latter's solution with the addition of traces of zinc, iron, sodium, lithium, and other salts, obtained a heavier growth of *Aspergillus niger* and *Penicillium glaucum* than in cultures to which none of the above were added, demonstrating that Raulin's solutions really resulted in stimulation. Ono in 1900 corroborated Richards's results and also worked out the effect of these salts on certain algae. He found that algae as a rule have their point of greatest stimulation at a much lower concentration of the salt but in other respects are similar to fungi. Richards (5) and Ono (6) determined that the economic coefficient of sugar is considerably lower in the cultures to which salts had been added than in the controls, proving that stimulated fungi require a smaller amount of carbohydrate food in proportion to the quantity of waste acid produced.

Since this time many other investigators have worked on this problem, obtaining similar results. Kahlenberg and True (7) formulated a law which they gave as an explanation of this stimulation phenomenon. They claim that since the chemical and physical properties of solutions are due to the properties of

the ions dissociated in the solution and of the undissociated molecules, then the physiological properties of a solution are due to the same factors. The authors worked out this theory with lupine seeds, the germination of which was accelerated by dilute solutions of electrolytic salts. They claimed that this stimulation was due to the hydrogen and metallic ions in the solutions. Heald (8) working with seeds of other plants obtained similar results and also attributed them to the electrolytic dissociation. Stevens (9) working with fungus spores applies this same theory. Iwanoff (10) claims that metallic salts are poisonous to plants in proportion to the atomic weight of the metal, the heavier metals being more poisonous than those of smaller atomic weight. In his opinion, the same is true of the alcohols, the lower alcohols (methyl and ethyl) being less poisonous than those of higher molecular content, such as propyl and butyl. Steinberg (11), in a recent paper on the stimulation of *Aspergillus*, attributes the stimulation to the increase in H ion content when zinc salts are added to the nutrient solution. It is not obvious, however, that the action of such oligodynamic substances is due to the hydrogen ion concentration alone, especially since we find non-electrolytes, such as ether, chloroform, and other anaesthetics, exerting a stimulatory influence. Carbon disulphide, being a very volatile liquid, which is non-dissociable in aqueous solution, also comes in this category.

Various authors have worked with ether and chloroform, although few have done anything with carbon disulphide. Townsend (12) in his experiments with *Avena* seeds found that if dormant seeds were exposed to a moist concentrated atmosphere of ether for a short time, or to a weaker atmosphere of ether for a longer period, the seeds germinated sooner and grew more rapidly than under normal conditions. This acceleration lasts for some time and gradually disappears. In a later paper (13) Townsend verified his results with other seeds: *Zea Mays*, *Cucurbita*, *Phaseolus*, etc. He also found that dry seeds, exposed to an atmosphere of HCN gas (14), germinated more rapidly than those not exposed although this advantage did not last for any appreciable time. Miss Latham (15), working with *Sterigmatocystis nigra*, determined that cultures of the fungus grown on nutrient media and exposed to chloroform vapor, produced a more luxuriant growth with a greater dry weight than similar

cultures unexposed. Furthermore the oxalic acid formation was lower per unit dry weight in the stimulated cultures.

Johannsen (16) was the first to discover that exposing dormant buds to an atmosphere impregnated with ether forced the buds to open earlier than normal. Chloroform has the same effect but is more powerful, less being needed to bring about the same result.

No attempt has been made to cover the whole field of the very voluminous literature on this subject. A comprehensive account may be found in Czapek's "Biochemie der Pflanzen," second edition, Vol. 1, page 147 *et seq.*, 1913.

Among the investigators who experimented with carbon disulphide, none used it in gaseous form but either in pure liquid state or in aqueous solution. Sirker (17) in Japan found that mulberry bushes, grown in soil previously treated with CS_2, produced more branches, higher plants and more leaves with a greater dry weight for each individual leaf than bushes grown in untreated soil. Koch (18) in 1912 found the same thing with other plants. Koch asserts that the carbon disulphide is not used as a carbon source, nor does it act as an insecticide in killing off the harmful lower organisms in the soil, since under such circumstances a larger amount of the CS_2 would be more beneficial. This, however, is not the case, a larger amount of the CS_2 being harmful, and the stimulation takes place only when the compound is added in minute quantities. Fred (19) in the same year stated that carbon disulphide added to the soil in dilute solutions stimulated the growth of soil bacteria, the nitrogen-fixing forms in particular, so that the quantity of nitrogen built up into higher compounds was measurably increased over normal. In a later paper Fred (21) corroborated his earlier results and concluded that while after treatment with carbon disulphide the soil showed a reduction in the number of microorganisms, it was followed by a great increase and an increase also in the by-products of their action. With relatively strong applications of carbondisulphide to the soil, corn and oats seemed deleteriously affected, while mustard and buckwheat were benefitted, as shown by increase in dry weight. In acid soil, clover is also stimulated.

The experiments described below, which further test the effect of carbon disulphide on plants, were performed in the

Botanical Laboratories of Barnard College, under the supervision of Professor H. M. Richards, for whose advice and assistance the writer is greatly indebted.

In this work, while no attempt was made to cover every type or condition of plant tissues, a number of widely differing kinds of material were employed. The experiments fall into three groups, each of which could profitably be elaborated beyond what was attempted here. These three categories are as given below and will be considered as separate topics in the following discussion.

1. Stimulation of seeds and seedlings.
2. Stimulation of buds.
3. Stimulation of certain fungi.

Carbon disulphide is a clear, practically colorless liquid when pure, very inflammable and volatile. It has a disagreeable odor, especially when impure, because of the decomposition into other sulphur compounds, hydrogen sulphide in particular (see Graham, 20). It is soluble in all proportions in alcohol, ether, and chloroform, but only slightly soluble in water. The solubility in water, according to Graham, varies inversely as the temperature, as follows:

At	12° –13°	C.	2.0	gms.	CS_2	dissolve	in	1	liter	of	water.
"	15° –16°	"	1.91	"	"	"	"	1	"	"	"
"	25° –27°	"	1.68	"	"	"	"	1	"	"	"
"	30° –33°	"	1.45	"	"	"	"	1	"	"	"

From these data, it was estimated by interpolation that at 20°–22° C. (average room temperature) about 1.8 gms. CS_2 dissolves in 1 liter of water.

In the following paper, the concentrations of the solutions used were determined in terms of molecular solutions. The molecular weight of carbon disulphide is 76.125, and if 1.8 grams dissolve in 1 liter of water at approximately room temperature, then a saturated aqueous solution is 0.0235 of a molecular solution. More dilute solutions were prepared from this, in fractions varying by 1/2000M. No attempt was made to determine or maintain the exact concentration closer than this, because carbon disulphide is so easily vaporized and a certain amount of that in solution is continually volatilizing out. In cases where the experiments lasted over a few days, the solutions were renewed at intervals of two or three days.

I. STIMULATION OF SEEDS AND SEEDLINGS

The first phase taken up was to determine if there was any stimulation of young seedlings by dilute solutions of carbon disulphide. Townsend (**12**, **13**, **14**) tested the effect of ether vapor and hydrogen cyanide gas on different kinds of seeds, by soaking seeds in water for twenty-four hours and then putting in an airtight damp chamber containing ether vapor. The exposed seeds germinated more quickly than unexposed controls, but whether left in ether chamber or removed immediately after germination, the stimulated seedlings soon lost their advantage, and five days after germination the control seeds equaled the stimulated in growth. Likewise dry seeds exposed to HCN gas for a short time and then soaked in water germinated more rapidly than seeds not treated with the hydrogen cyanide. However in every case, growth was equal after a week.

In the following experiments, wheat grains (*Triticum sativum*) were used. One hundred grains were soaked in the CS_2 solution for twenty-four hours. Seed pans were filled with moist sphagnum, covered with damp cheese cloth, and grains planted out on top of this. They were then covered with a second layer of cheese cloth, with a pad of moist sphagnum on top of the whole. Pans were kept under a shelf in the greenhouse for three or four days, taking care not to allow the sphagnum to dry out. The seedlings were then uncovered, epicotyls measured and the average taken of those germinated. It was found that the saturated solution completely inhibited growth, while the seedlings in the other solutions grew as shown in TABLE I.

TABLE I

AVERAGE GROWTH IN MILLIMETERS OF EPICOTYLS OF WHEAT SEEDLINGS AFTER BEING SOAKED IN FOLLOWING CS_2 SOLUTIONS FOR 24 HOURS AND LEFT TO GERMINATE FOR 3 OR 4 DAYS

SERIES I. Germinated 4 days

Exp.	A.	B.	C.	Average	Avg. per day
M/2,000			37.7	37.7	9.4
M/4,000	39.7	35.2	38.5	37.8	9.4
M/6,000	40.6	29.2		34.9	8.7
M/8,000	34.8	31.1	41.3	39.1	9.8
M/12,000	38.3	34.1		36.2	9.1
M/16,000	42.7	33.2	37.6	37.8	9.5
M/22,000	41.2	28.9	43.4	37.8	9.5
M/32,000	40.0	36.6	39.4	38.7	9.7
M/40,000			41.5	41.5	10.4
Control	35.8	33.0	36.6	35.1	8.8

TABLE I (*con.*)

SERIES II. Germinated 3 days

Exp.	D.	E.	Average	Avg. per day
M/2,000	13.6	10.0	11.8	3.9
M/4,000	13.3	13.8	13.6	4.5
M/8,000	16.8	14.5	15.7	5.2
M/16,000	14.7	13.7	14.2	4.7
M/22,000	14.9	14.2	14.6	4.9
M/32,000	18.7	14.4	16.6	5.5
M/40,000	12.7	15.3	14.0	4.7
Control	11.1	13.6	13.3	4.4

Although these results show some irregularities due to the comparatively small number of cases, they also reveal a marked stimulation of growth especially in the solutions between M/22,000 and M/40,000 in CS_2 content. The stimulation in the three day experiments is proportionally greater than in the four day instances, showing that the stimulation tends to diminish, and growth tends to approach the normal after an interval, just as Townsend found.

An experiment with *Vicia Faba* seedlings was carried out in the following manner. The seeds were planted and allowed to germinate until the hypocotyls reached a convenient length to measure. A number 400 cc. bottles were almost filled with Knop's nutrient solution and enough CS_2 solution was added to make of desired concentration. The bottles were then fitted with corks, each cork having three holes bored in it, which were just small enough to prevent the seeds from falling through. The seedlings grown as above, were then washed in distilled water, hypocotylsm easured, and arranged in culture bottles so that seed rested on top of cork and hypocotyl extended through the hole into the solution. The bottles were placed in a dark chamber in the green house (temperature varying from 18° to 25° C.), the hypocotyls were measured every twenty-four hours and the daily growth computed.

TABLE II

AVERAGE GROWTH IN MILLIMETERS OF THREE HYPOCOTYLS OF *Vicia Faba* SEEDLINGS, PLACED IN NUTRIENT SOLUTIONS CONTAINING CS_2 TO MAKE OF FOLLOWING CONCENTRATION, EACH EXPERIMENT COMPRISING TWELVE SEEDLINGS

	M/2,000	M/4,000	M/6,000	M/8,000	M/20,000	M/40,000	Control
Exp. A.							
1st day	5.3	6.5	13.0		13.7		7.0
2nd "	2.2	5.4	11.7		16.1		9.5
Total	7.5	11.9	24.7		29.8		16.5
Avg.	3.8	6.0	12.4		14.9		8.3
Exp. B.							
1st day		18.2	18.2	22.7	22.9	17.8	18.9
2nd "		19.4	23.4	21.6	21.0	16.2	19.6
3rd "		21.4	19.0	19.7	15.8	8.1	14.4
4th "		19.2	19.2	23.5	17.0	17.7	16.3
Total		78.2	79.8	87.5	76.7	59.8	69.2
Avg.		19.6	20.0	21.9	19.2	15.0	17.3
Exp. C.							
1st day	16.6	14.6	13.6	13.7	14.7	16.6	19.3
2nd "	10.5	16.0	18.7	21.8	21.6	16.0	17.5
3rd "	14.1	18.4	18.0	29.0	26.7	15.5	19.7
Total	41.2	49.0	50.3	64.5	63.0	48.1	56.5
Avg.	13.7	16.3	16.8	21.5	21.0	16.0	18.8
Exp. D.							
1st day	9.5	16.8	10.8	20.0	39.0	1.5	19.8
2nd "	7.0	11.5	11.0	18.0	12.5	11.0	16.5
3rd "	8.0	14.0	12.9	24.5	18.5	13.2	17.0
Total	24.5	42.3	34.7	62.5	70.0	25.7	53.3
Avg.	8.2	14.1	11.6	20.8	23.3	8.6	17.8
Total average of the four experiments (i.e. twelve examples).							
	8.6	14.0	15.2	21.4	19.6	13.2	15.6

TABLE II shows a distinct stimulation in the growth of hypocotyls of *Vicia* seedlings, in the M/6,000 to M/20,000 CS_2 solutions, the average greatest stimulation being in the M/8,000 dilution, although the M/20,000 shows a greater acceleration in some instances. In the M/40,000 concentration, the CS_2 content has become so dilute that it no longer has any effect on growth. In the higher concentrations, the M/6,000 solution caused a marked stimulation in Exp. A and B, although in other cases

growth is not as great as normal in these dilutions. Although the M/4,000 and M/2,000 solutions do not entirely inhibit growth, they do retard it below normal. Complete inhibition was found in the saturated CS_2 solution, but no dilutions were tried between that and the above.

Koch (18) tried similar experiments with *Helianthus annuus* and *Cucurbita Pepo* seeds, letting the seeds germinate and then placing them in the dark, with their hypocotyls in solutions containing 0.1 and 0.05 cc. CS_2 to 1000 cc. water for thirteen to fourteen hours. In one case only, in the solution containing 0.05 cc. CS2 to the liter(about M/150 solution), did he obtain growth higher than normal. This being only a single instance was probably an accident due to the solution being weaker than intended and cannot in any sense be called a stimulation. Koch did not try any solutions weaker than this and therefore did not reach the stimulatory region but really only determined that carbon disulphide acted as an inhibitory agent.

2. STIMULATION OF DORMANT TWIGS

Johannsen (16), investigating the effect of ether on dormant twigs, found that they were stimulated so that the buds opened sooner and developed more rapidly when exposed to ether vapor for twenty-four to forty-eight hours, than when unexposed. When using chloroform a much smaller amount was necessary to produce the same result (9 grams of chloroform giving the same acceleration as 40 grams of ether).

With these results in view, experiments were carried out to see if vaporized carbon disulphide would stimulate buds to open. Willow twigs were cut from trees outdoors which had been subjected to winter conditions and were probably frozen in spite of the general mildness of the winter. The lower three or four inches of the stem were placed in a bottle of water and a large bell-jar put over them. Pieces of filter paper, moistened with 10 cc. of carbon disulphide were quickly inserted under the bell-jar. The whole was placed in a pan of water making a water seal so that the carbon disulphide, which vaporizes almost immediately, could not escape from the bell-jar. The twigs were left in this atmosphere (approximately saturated with CS_2 gas) for periods ranging from ten minutes to eighteen hours. They were then removed, the stems were put into fresh water and with a control placed in the greenhouse.

The results of a number of experiments can be summarized as follows. After three days, the twigs exposed ten and twenty minutes began to develop, the buds showing patches of green at the tips. After seven days, the buds on the twigs exposed thirty minutes were open considerably. One of the hour experiments showed slight greening of the upper buds but other specimens gave no evidence of development. After nine days, the control (not exposed to CS_2 at all) had two buds developing. Twigs exposed ten, twenty and thirty minutes continued to show better bud development for two to three weeks longer, after which the condition of all tended to become the same. Twigs exposed for one and a half hours or for two hours started to open but after a day or so became brown and withered, while those exposed for four hours or more showed no signs of development at any time, indicating that the protoplasm itself must have been killed.

3. STIMULATION OF CERTAIN FUNGI

As stated above, there has been a vast amount of work done on stimulation of fungi by metallic salts and other chemicals. Because of this, a number of experiments were set up to test the effect of carbon disulphide on fungi.

To determine the effect of dilute solutions of carbon disulphide on the germination of spores of *Rhizopus nigricans* and *Sterigmatocystis nigra*, hanging drop slides were used. Small glass rings were attached to microscope slides by means of a solution of dextrin in water (vaseline is not practicable since carbon disulphide is very soluble in it). The medium used for the germination of the spores was prepared according to the following formula (see Richards, 4):

Potassium phosphate	0.5 gm.
Magnesium sulphate	0.25 gm.
Ammonium nitrate	1.0 gm.
Ferrous sulphate	trace
Sugar	5.0 gms.
Distilled water	100 cc.

To this was added 5 gms. of gelatine, and the mixture was then heated in water bath. When the gelatine was completely solved, the medium was filtered tubed (10 cc. to the tube) and sterilized. Before the gelatine hardened, the CS_2 solution was added to make of desired concentration.

A small drop of this gelatine was put on a clean cover glass and inoculated with fungus spores. After inverting the cover glass, and sealing on to the glass ring the slides were left standing at room temperature under a bell-jar containing moist filter paper to prevent slides from drying up. After some hours, slides were examined microscopically for germination, and where possible the germination-tubes were measured by means of a standardized micrometer eye-piece.

According to TABLE III. solutions of carbon disulphide in nutrient gelatine varying from M/16,000 to M/40,000 in concentration, stimulate spores of *Rhizopus nigricans* and *Sterigmatocystis nigra* to germinate sooner than in the same media but without the CS_2. The point of greatest stimulation lies between the M/32,000 and the M/40,000 solutions.

In another type of experiment with *Sterigmatocystis* spores, the stimulation of growth was measured by the increase in dry

TABLE III

AVERAGE GROWTH IN MICRONS OF 10 GERMINATION TUBES OF FUNGOUS SPORES, INOCULATED ON NUTRIENT MEDIA TO WHICH CS_2 HAD BEEN ADDED

RHIZOPUS NIGRICANS

No. of hours	M/800	M/8,000	M/16,000	M/22,000	M/32,000	M/40,000	Control
Exp. A.							
24	10.6	11.9	59.9	over 300	over 300	over 300	250.
Exp. B.							
13½	no	no	no	no	6.7	52.6	no
15	no	no	no	13.9	16.4	83.2	no
18	5.0	no	no	70.0	50.4	over 300	45.9
20½	26.9	no	9.5	103.9	76.7	over 300	59.5
Exp. C.							
13	29.7	57.4	over 300	139.2	over 300	over 300	no
14	59.6	over 300	over 300	over 300	over 300	over 300	no
17	over 300	" "	" "	" "	" "	" "	98.6
Exp. D.							
13	129.6	203.6	——	13.2	8.1	10.1	no
15	281.1	313.0	——	22.7	24.1	46.5	14.8
18	over 300	over 300	——	44.3	73.6	79.3	44.5
Exp. E.							
14	67.5	68.3	——	20.4	39.2	21.0	10.9
17	101.6	148.1	——	62.2	84.3	43.4	25.5
19	127.4	over 300	——	91.6	96.9	88.2	52.6

TABLE III (*con.*)

STERIGMATOCYSTIS NIGRA

No. of hours	M/800	M/8,000	M/16,000	M/22,000	M/32,000	M/40,000	Control
Exp. A.							
29½	44.5	over 300	50.7	——	56.5	20.4	no
48	126.2	" "	over 300	——	over 300	over 300	224.9
Exp. B.							
15	no	no	no	no	no	6.4	no
20	no	no	no	no	no	75.6	no
35	no	no	no	no	no	over 300	no
65	no	—	over 300	over 300	over 300	" "	start
Exp. C.							
19	no	no	no	no	117.0	124.9	no
25	no	no	no	137.5	over 300	over 300	no
27	no	no	no	over 300	" "	" "	no
68	no	no	no	" "	" "	" "	no
91	no	no	over 300	" "	" "	" "	start
Exp. D.							
19	no	no	78.4	57.1	over 300	152.3	no
25	no	no	over 300	over 300	" "	over 300	no
74	no	no	" "	" "	" "	" "	start

weight of the germinating hyphae. In their experiments 150cc. Erlenmeyer flasks were used as culture bottles and, with pipettes and other apparatus, were cleansed with cleaning solution, rinsed in tap water a number of times, then in distilled water and finally in double distilled water. The same solution as in the former experiment, but without the gelatine and with double distilled water was employed as a culture medium. The trace of ferrous sulphate was introduced by adding one drop of a saturated solution of ferrous sulphate in double distilled water.

After the nutrient solution was made up, it was inoculated in bulk with the *Sterigmatocystis* spores, and 50 cc. of the inoculated solution pipetted into each flask. The aqueous CS_2 solution (also prepared with double distilled water) was added last. The flasks were then corked by means of a mercury air trap, which would allow air to come into the flask, but would not allow any gas to escape from the flask and thus change the CS_2 ratio.

After being stoppered, the flasks were left in a dark chamber at room temperature and, as a preventive measure, the controls were put in a different compartment from those to which carbon disulphide had been added. After five days, the flasks were removed, pads filtered off on weighed filter paper and dried in hot air oven at 70° to dry weight. No attempt was made to determine the CO_2 or acid production, although this would have been an interesting point to investigate.

Although growth was not wholly normal in the controls, presumably due to lack of adequate circulation which may have caused carbon dioxide to accumulate, nevertheless the gross appearance of the stimulated was strikingly different from that of control specimens. The solutions containing CS_2 in the most optimum concentrations bore tough pads, thicker and considerably heavier than normal. All the stimulated pads were wrinkled and curled, and slightly yellow on the under surface. Practically no spores were produced, although in some cases a few yellow sporangia were observed. The control felts on the other hand were thin and tender in texture, and more or less covered with black spores. However, if further experiments were to be carried out, a more perfect system of maintaining the concentration of CS_2 in the flasks would have to be devised in order to obtain absolutely normal controls.

TABLE IV

DRY WEIGHT IN MILLIGRAMS OF CULTURES OF STERIGMATOCYSTIS NIGRA, GROWN IN NUTRIENT SOLUTION TO WHICH CS_2 HAD BEEN ADDED

Exp.	Control. No CS_2	M/80,000	M/40,000	M/20,000	M/10,000	M/5,000
A	439	838	800	740	585	270
B	442	1028	815	748	675	370
C	530	765	1035	495	490	—
D	578	788	740	810	540	—
Avg.	497	855	848	698	573	320

The results of TABLE IV are sufficient to indicate that there is a marked stimulation in cultures to which carbon disulphide has been added. The region of greatest stimulation is in the flasks M/80,000 and M/40,000 CS_2 solutions, the more dilute concentration being slightly more advantageous than the other.

Complete inhibition was not found in any of the experiments tried, although the flasks containing M/5,000 solution only produced felts of approximately three-fourths of the normal weight. In some instances the M/10,000 acted slightly as an inhibitor so that growth below normal was produced.

SUMMARY

All things considered, the results of this investigation lead one to conclude that carbon disulphide acts on plants as many other chemical stimulants do. When applied either in aqueous solution or in vaporized condition it inhibits growth, if given in too concentrated a solution or if vapor is used for too long a time.

When used in dilute amounts, carbon disulphide has the ability to stimulate:

(1) Dormant protoplasm, as in the case where twigs exposed to CS_2 vapor for a short period of time quickly resumed their growth;

(2) Active protoplasm, as in case where the hypocotyls of *Vicia* seedlings elongated more rapidly upon the addition of small amounts of CS_2;

(3) Conidial spores of certain fungi which germinated sooner and produced germination tubes elongating more rapidly, the stimulation causing also causes an increase in dry weight.

Carbon disulphide acts also as other stimulants do, in that the acceleration of growth lasts only for a certain period of time, and then growth tends to reach normal again. This fact was shown in the twig experiments and those with *Triticum* grains. The same would probably be true of the other experiments if left running for a sufficient length of time.

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The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to foresty, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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